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INCLUDING

CEYLON AND BURMA.

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FRESHWATER SPONGES, HYDROIDS & POLYZOA.

BY

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EDITOR'S PREFACE.

DR N ANNANDALE'S volume on the Freshwater SPONGES, POLYZOA, and HYDRIDA contains an account of three of the chief groups of freshwater organisms. Although he deals mainly with Indian forms the book contains an unusually full account of the life-history and bionomics of freshwater Sponges, Polyzoa, and Hydrozoa.

I have to thank Dr. Annandale for the great care he has taken in the preparation of his manuscript for the press, and also the Trustees of the Indian Museum, Calcutta, for their kindness in placing material at the disposal of the Author

A. E SHIPLEY.

Christ's College, Cambridge,
March 1911

SYSTEMATIC INDEX.

GENERAL INTRODUCTION TO THE VOLUME

ALTHOUGH some zoologists have recently revived the old belief that the sponges and the cœlenterates are closely allied, no one in recent times has suggested that there is any morphological relationship between either of these groups and the polyzoa. Personally I do not think that any one of the three groups is allied to any other so far as anatomy is concerned, but for biological reasons it is convenient to describe the freshwater representatives of the three groups in one volume of the "Fauna."

Indeed, I originally proposed to the Editor that this volume should include an account not only of the freshwater species, but of all those that have been found in stagnant water of any kind. It is often difficult to draw a line between the fauna of brackish ponds and marshes and that of pure fresh water or that of the sea, and this is particularly the case as regards the estuarine tracts of India and Burma.

Pelseneer* has expressed the opinion that the Black Sea and the South-east of Asia are the two districts in the world most favourable for the study of the origin of a freshwater fauna from a marine one The transition in particular from the Bay of Bengal, which is much less salt than most seas, to the lower

* "L'origine des animaux d'eau douce," Bull de l'Acad roy de Belgique (Classe des Sciences), No 12, 1905, p 724

reaches of the Ganges or the Brahmaputra is peculiarly easy, and we find many molluscs and other animals of marine origin in the waters of these rivers far above tidal influence Conditions are unfavourable in the rivers themselves for the development and multiplication of organisms of many groups, chiefly because of the enormous amount of silt held in suspension in the water and constantly being deposited on the bottom, and a much richer fauna exists in ponds and lakes in the neighbourhood of the rivers and estuaries than in running water I have only found three species of polyzoa and three of sponges in running water in India, and of these six species, five have also been found in ponds or lakes I have, on the other hand, found three cœlenterates in an estuary, and all three species are essentially marine forms, but two have established themselves in ponds of brackish water, one (the sea-anemone *Sagartia schilleriana*) undergoing in so doing modifications of a very peculiar and interesting nature It is not uncommon for animals that have established themselves in pools of brackish water to be found occasionally in ponds of fresh water; but I have not been able to discover a single instance of an estuarine species that is found in the latter and not in the former

For these reasons I intended, as I have said, to include in this volume descriptions of all the cœlenterates and polyzoa known to occur in pools of brackish water in the estuary of the Ganges and elsewhere in India, but as my manuscript grew I began to realize that this would be impossible without including also an amount of general introductory matter not justified either by the scope of the volume or by special knowledge on the part of its author I have, however, given in the introduction to each part a list of the species found in stagnant brackish water with a few notes and references to descriptions

Biological Peculiarities of the Sponges, Cœlenterates, and Polyzoa of Fresh Water

There is often an external resemblance between the representatives of the sponges, cœlenterates, and polyzoa that causes them to be classed together in popular phraseology as "zoophytes", and this resemblance is not merely a superficial one, for it is based on a similarity in habits as well as of habitat, and is correlated with biological phenomena that lie deeper than what are ordinarily called habits. These phenomena are of peculiar interest with

regard to difficult questions of nutrition and reproduction that perhaps can only be solved by a close study of animals living together in identical conditions and exhibiting, apparently in consequence of so living, similar but by no means identical tendencies, either anatomical or physiological, in certain directions

One of the most important problems on which the study of the sponges, cœlenterates, and polyzoa of stagnant water throws light is that of the production of resting buds and similar reproductive bodies adapted to withstand unfavourable conditions in a quiescent state and to respond to the renewal of favourable conditions by a renewed growth and activity.

Every autumn, in an English pond or lake, a crisis takes place in the affairs of the less highly organized inhabitants, and preparations are made to withstand the unfavourable conditions due directly or indirectly to the low winter temperature of the water the individual must perish but the race may be preserved At this season *Hydra*, which has been reproducing its kind by means of buds throughout the summer, develops eggs with a hard shell that will lie dormant in the mud until next spring, the phylactolæmatous polyzoa produce statoblasts, the ctenostomatous polyzoa resting-buds ("hibernacula"), and the sponges gemmules. Statoblasts, hibernacula, and gemmules are alike produced asexually, but they resemble the eggs of *Hydra* in being provided with a hard, resistant shell, and in having the capacity to lie dormant until favourable conditions return

In an Indian pond or lake a similar crisis takes place in the case of most species, but it does not take place at the same time of year in the case of all species. Unfortunately the phenomena of periodic physiological change have been little studied in the fresh-water fauna of most parts of the country, and as yet we know very little indeed of the biology of the Himalayan lakes and tarns, the conditions in which resemble those to be found in similar masses of water in Europe much more closely than they do those that occur in ponds and lakes in a tropical plain. In Bengal, however, I have been able to devote considerable attention to the subject, and can state definitely that some species flourish chiefly in winter and enter the quiescent stage at the beginning of the hot weather (that is to say about March), while others reach their maximum development during the "rains" (July to September) and as a rule die down during winter, which is the driest as well as the coolest time of year.

The following is a list of the forms that in Bengal are definitely known to produce hard-shelled eggs, gemmules, resting-buds, or statoblasts only or most profusely at the approach of the hot weather and to flourish during winter —

Spongilla carteri
Spongilla alba
Spongilla alba var *bengalensis*
Spongilla crassissima
Hydra vulgaris
Victorella bengalensis
Plumatella fruticosa
Plumatella emarginata
Plumatella javanica

The following forms flourish mainly during the "rains" —

Spongilla lacustris subsp *reticulata*
Trochospongilla latouchiana
Trochospongilla phillottiana
Stolella indica.

The following flourish throughout the year :—

Spongilla proliferens
Hislopia lacustris

It is particularly interesting to note that three of the species that flourish in the mild winter of Bengal, namely *Hydra vulgaris*, *Plumatella emarginata*, and *P fruticosa*, are identical with species that in Europe perish in winter There is evidence, moreover, that the statoblasts of the genus to which two of them belong burst more readily, and thus give rise to new colonies, after being subjected to a considerable amount of cold In Bengal they only burst after being subjected to the heat of the hot weather Does extreme heat have a similar effect on aquatic organisms as extreme cold? There is some evidence that it has

The species that flourish in India during the rains are all forms which habitually live near the surface or the edge of ponds or puddles, and are therefore liable to undergo desiccation as soon as the rains cease and the cold weather supervenes

The two species that flourish all the year round do not, properly speaking, belong to one category, for whereas *Hislopia lacustris*

produces no form of resting reproductive body but bears eggs and spermatozoa at all seasons, *Spongilla proliferens* is a short-lived organism that undergoes a biological crisis every few weeks, that is to say, it begins to develop gemmules as soon as it is fully formed, and apparently dies down as soon as the gemmules have attained maturity The gemmules apparently lie dormant for some little time, but incessant reproduction is carried on by means of external buds, a very rare method of reproduction among the freshwater sponges.

The facts just stated prove that considerable specific idiosyncrasy exists as regards the biology of the sponges, hydroids, and polyzoa of stagnant water in Bengal, but an even more striking instance of this phenomenon is afforded by the sponges *Spongilla bombayensis* and *Corvospongilla lapidosa* in Bombay These two sponges resemble one another considerably as regards their mode of growth, and are found together on the lower surface of stones. In the month of November, however, *C lapidosa* is in full vegetative vigour, while *C bombayensis*, in absolutely identical conditions, is already reduced to a mass of gemmules, having flourished during the "rains" It is thus clear that the effect of environment is not identical in different species This is more evident as regards the groups of animals under consideration in India (and therefore probably in other tropical countries) than it is in Europe. The subject is one well worthy of study elsewhere than in India, for it is significant that specimens of *S. bombayensis* taken in November in S Africa were in a state of activity, thus contrasting strongly with specimens taken at the same time of year (though not at the same season from a climatic point of view) in the Bombay Presidency

Geographical Distribution of the Indian Species

The geographical distribution of the lower invertebrates of fresh and of stagnant water is often an extremely wide one, probably because the individual of many species exists at certain seasons or in certain circumstances in a form that is not only resistant to unfavourable environment, but also eminently capable of being transported by wind or currents We therefore find that some genera and even species are practically cosmopolitan in their range, while others, so far as our knowledge goes, appear to have an extraordinarily discontinuous distribution. The latter

phenomenon may be due solely to our ignorance of the occurrence of obscure genera or species in localities in which they have not been properly sought for, or it may have some real significance as indicating that certain forms cannot always increase and multiply even in those localities that appear most suitable for them. As an example of universally distributed species we may take the European polyzoa of the genus *Plumatella* that occur in India, while of species whose range is apparently discontinuous better examples could not be found than the sponges *Trochospongilla pennsylvanica* and *Spongilla crateriformis*, both of which are only known from N. America, the British Isles, and India.

My geographical list of the species of sponges, cœlenterates, and polyzoa as yet found in fresh water in India is modelled on Col. Alcock's recently published list of the freshwater crabs (Potamonidæ) of the Indian Empire *. I follow him in accepting, with slight modifications of my own, Blanford's physiographical rather than his zoogeographical regions, not because I think that the latter have been or ought to be superseded so far as the vertebrates are concerned, but rather because the limits of the geographical distribution of aquatic invertebrates appear to depend on different factors from those that affect terrestrial animals or even aquatic vertebrates.

"Varieties" are ignored in this list, because they are not considered to have a geographical significance. The parts of India that are least known as regards the freshwater representatives of the groups under consideration are the valley of the Indus, the lakes of Kashmir and other parts of the Himalayas, the centre of the Peninsula, and the basin of the Brahmaputra. Those that are best known are the districts round Bombay, Calcutta, Madras and Bangalore, Travancore and Northern Tenasserim. Little is known as regards Ceylon, and almost nothing as regards the countries that surround the Indian Empire, a few species only having been recorded from Yunnan and the Malay Peninsula, none from Persia, Afghanistan, or Eastern Turkestan, and only one from Tibet. Professor Max Weber's researches have, however, taught us something as regards Sumatra and Java, while the results of various expeditions to Tropical Africa are beginning to cast light on the lower invertebrates of the great lakes in the centre of that continent and of the basin of the Nile.

* Cat. Ind. Dec. Crust. Coll. Ind. Mus., part i, fasc. ii (Potamonidæ), 1910.

It is not known to what altitude the three groups range in the Himalayas and the hills of Southern India No sponge has been found in Indian territory at an altitude higher than that of Bhim Tal in Kumaon (4,500 feet), and *Hydra* is only known from the plains, but a variety of *H oligactis* was taken by Capt. F H. Stewart in Tibet at an altitude of about 15,000 feet. *Plumatella diffusa* flourishes at Gangtok in Sikhim (6,100 feet), and I have found statoblasts of *P fruticosa* in the neighbourhood of Simla on the surface of a pond situated at an altitude of about 8,000 feet; Mr R Kirkpatrick obtained specimens of the genus in the Botanical Gardens at Darjiling (6,900 feet), and two species have been found at Kurseong (4,500–5,000 feet) in the same district.

GEOGRAPHICAL LIST OF THE FRESHWATER SPONGES, HYDROIDS, AND POLYZOA OF INDIA, BURMA, AND CEYLON

[A * indicates that a species or subspecies has only been found in one physiographical region or subregion so far as the Indian Empire is concerned, a † that the species has also been found in Europe, a § in North America, a ✻ in Africa, and a ○ in the Malay Archipelago.]

1. Western Frontier Territory *.

(Baluchistan, the Punjab, and the N.W Frontier Province.)

SPONGES —

1 *Spongilla (Eunapius) carteri* †○ (Lahore)

HYDROIDS —

1 *Hydra oligactis* †§ (Lahore)

POLYZOA —

1 *Plumatella fruticosa* †§ (Lahore).

2 *Plumatella diffusa* †§ (Lahore)

2 Western Himalayan Territory.

(Himalayas from Hazara eastwards as far as Nepal)

SPONGES.—

1 *Spongilla (Eunapius) carteri* †○ (Bhim Tal)

2 *Ephydatia meyeni* ○ (Bhim Tal)

HYDROIDS.—None known (*Hydra oligactis* recorded from Tibet)

POLYZOA —

1 *Plumatella allmani* † (Bhim Tal)

2 *Plumatella fruticosa* † § (Simla).

3 *Lophopodella carteri* ✻ (Bhim Tal)

* I include Baluchistan in this territory largely for climatic reasons

3 North-Eastern Frontier Territory

(Sikhim, Darjiling and Bhutan, and the Lower Brahmaputra Drainage-System)

SPONGES —

Spongilla proliferens ○ (Assam)

HYDROIDS —None known

POLYZOA —

1 *Plumatella fruticosa* † (Kurseong and Assam)
2 *Plumatella diffusa* † § (Sikhim)
3 *Plumatella javanica* ○ (Kurseong)

4 Burma Territory

(Upper Burma, Arrakan, Pegu, Tenasserim)

SPONGES —

1 *Spongilla (Euspongilla) proliferens* ○ (Upper Burma, Pegu)
2 *Spongilla (Euspongilla) crateriformis* † § (Tenasserim)
3 *Spongilla (Eunapius) carteri* † ○ (Upper Burma, Pegu, Tenasserim)
4 *Trochospongilla latouchiana* (Tenasserim)
5 *Trochospongilla phillottiana* (Tenasserim)
6 *Tubella vesparioides* * (Tenasserim)
7 *Corvospongilla burmanica* * (Pegu)

HYDROIDS —

1 *Hydra vulgaris* † § (Upper Burma and Tenasserim)

POLYZOA —

1 *Plumatella emarginata* † § (Pegu, Upper Burma)
2 *Plumatella allmani* † (Tenasserim)
3 *Pectinatella burmanica* (Tenasserim)
4 *Hislopia lacustris* (Pegu)

5 *a*. Peninsular Province—Main Area

(The Peninsula east of the Western Ghats)

SPONGES —

1 *Spongilla (Euspongilla) lacustris* subsp *reticulata* (Orissa, Madras)
2 *Spongilla (Euspongilla) proliferens* ○ (Madras)
3 *Spongilla (Euspongilla) alba* * (N Madras, Orissa, Hyderabad)
4 *Spongilla (Euspongilla) hemephydatia* * (Orissa)
5 *Spongilla (Euspongilla) crateriformis* † §
6 *Spongilla (Eunapius) carteri* † ○
7 *Spongilla (Eunapius) gemmina* * (Bangalore)
8 *Spongilla (Stratospongilla) bombayensis* * (Mysore)
9 *Dosilia plumosa* (N Madras)

HYDROIDS —

1 *Hydra vulgaris* † §

POLYZOA —

1 *Plumatella fruticosa* † (Madras, Bangalore)
2 *Lophopus* (? *Lophopodella*), sp (Madras)
3 *Pectinatella burmanica* (Orissa)
4 *Victorella bengalensis* (Madras)
5 *Hislopia lacustris* (Nagpur)

5 b Peninsular Province—Malabar Zone

(Western Ghats from Tapti R to Cape Comorin and eastwards to the sea)

SPONGES —

1 _Spongilla (Euspongilla) lacustris_ subsp _reticulata_ (W Ghats)
2 _Spongilla (Euspongilla) proliferens_ ○ (Cochin)
3 _Spongilla (Euspongilla) alba_ *
4 _Spongilla (Euspongilla) cinerea_ *
5 _Spongilla (Euspongilla) travancorica_ * (Travancore)
6 _Spongilla (Euspongilla) crateriformis_ †§ (Cochin)
7 _Spongilla (Eunapius) carteri_ †○
8 _Spongilla (Stratospongilla) indica_ * (W Ghats)
9 _Spongilla (Stratospongilla) bombayensis_ * (Bombay, W Ghats)
10 _Spongilla (Stratospongilla) ultima_ * (Travancore)
11 _Pectispongilla aurea_ * (Travancore, Cochin)
12 _Ephydatia meyeni_ ○ (Bombay, Travancore)
13 _Dosilia plumosa_ (Bombay)
14 _Trochospongilla pennsylvanica_ *†§ (Travancore)
15 _Corvospongilla lapidosa_ * (W Ghats)

HYDROIDS —None recorded

POLYZOA —

1 _Fredericella indica_ * (W Ghats and Travancore)
2 _Plumatella fruticosa_ † (Bombay)
3 _Plumatella javanica_ ○ (Travancore)
4 _Plumatella tanganyikae_ * *(W Ghats)
5 _Lophopodella carteri_ * (Bombay, W Ghats)

6 Indo-Gangetic Plain

(From Sind to the Brahmaputra)

SPONGES —

1 _Spongilla (Euspongilla) lacustris_ subsp _reticulata_ (Gangetic delta)
2 _Spongilla (Euspongilla) proliferens_ ○ (Lower Bengal, etc)
3 _Spongilla (Euspongilla) alba_ * (Lower Bengal)
4 _Spongilla (Euspongilla) crateriformis_ †§
5 _Spongilla (Eunapius) carteri_ †○ (Lower Bengal, etc)
6 _Spongilla (Eunapius) fragilis_ subsp _calcuttana_ * (Lower Bengal)
7 _Spongilla (Eunapius) crassissima_ (Bengal)
8 _Ephydatia meyeni_ ⊙ (Lower Bengal)
9 _Trochospongilla latouchiana_ (Lower Bengal)
10 _Trochospongilla phillottiana_ (Lower Bengal)

HYDROIDS —

1 _Hydra vulgaris_ †§

POLYZOA —

1 _Plumatella fruticosa_ †
2 _Plumatella emarginata_ †§
3. _Plumatella javanica_ ○ (Lower Bengal)
4 _Plumatella diffusa_ †§
5 _Plumatella allmani_ †
6 _Plumatella punctata_ †§ (Lower Bengal)
7 _Stolella indica_ * (Lower Bengal, United Provinces)
8 _Victorella bengalensis_ (Lower Bengal)
9 _Hislopia lacustris_ (United Provinces, N Bengal)
9 a _Hislopia lacustris_ subsp _moniliformis_ * (Lower Bengal)

7 Ceylon

SPONGES —

1 *Spongilla* (*Euspongilla*) *proliferens* ○

2 *Spongilla* (*Eunapius*) *carteri* †⊙.

HYDROIDS —

1 *Hydra vulgaris* †§

POLYZOA —

1 ? *Plumatella emarginata* †§

2 *Pectinatella burmanica*

The most striking feature of this list is the evidence it affords as to the distinct character of the fauna of the Malabar Zone, a feature that is also remarkably clear as regards the Potamonidæ, one genus of which (*Gecarcinucus*) is peculiar, so far as India is concerned, to that zone As regards the sponges we may note the occurrence of no less than three species of the subgenus *Stratospongilla*, which has not been found elsewhere in India except on one occasion in Mysore, and of a species of the genus *Corvospongilla*, which is unknown from the rest of Peninsular India and from the Himalayas The genus *Pectispongilla* is only known from the Malabar Zone Among the polyzoa the genus *Fredericella* * appears to be confined, so far as the Indian and Burmese fauna is concerned, to the Malabar Zone, and the same is true as regards the group of species to which *Plumatella tanganyikæ*, an African form, belongs

A further examination of the list of Malabar species and a consideration of allied forms shows that the majority of the forms restricted to the Malabar Zone are either African or else closely allied to African forms The genus *Corvospongilla*, except for one Burmese species, is otherwise peculiar to Tropical Africa, while *Stratospongilla*, although not confined to Africa, is more prolific in species in that continent than in any other *Spongilla* (*Stratospongilla*) *bombayensis* has only been found in Bombay, the Western Ghats, Mysore, and Natal, and *Plumatella tanganyikæ* only in the Western Ghats and Central Africa The genus *Fredericella* (which also occurs in Europe, N America, and Australia) is apparently of wide distribution in Africa, while *Lophopodella* (which in India is not confined to the Malabar Zone) is, except for a Japanese race of the Indian species, restricted outside India, so far as we know, to East Africa

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* Mr S W. Kemp recently obtained at Mangaldai, near the Bhutan frontier of Assam, a single specimen of what may be a species of *Fredericella*

A less definite relationship between the sponges and polyzoa of the Malabar Zone and those of countries to the east of India is suggested by the following facts —

(1) The occurrence of the genus *Corvospongilla* in Burma,
(2) the occurrence of the subgenus *Stratospongilla* in Sumatra, China, and the Philippines,
(3) the occurrence of a race of *Lophopodella carteri* in Japan,
(4) the occurrence of a species allied to *Plumatella tanganyikæ* in the Philippines.

It will be noted that in each of these instances the relationship extends to Africa as well as to the Eastern countries, and is more marked in the former direction The species of *Stratospongilla*, moreover, that occurs in Sumatra (*S sumatrensis*) also occurs in Africa, while those that have been found in China and the Philippines are aberrant forms

At first sight it might appear that these extra-Indian relationships might be explained by supposing that gemmules and statoblasts were brought to the Malabar Coast from Africa by the aerial currents of the monsoon or by marine currents and carried from India eastwards by the same agency, this agency being insufficient to transport them to the interior and the eastern parts of the Peninsula The work of La Touche * on wind-borne foraminifera in Rajputana is very suggestive in this direction, but that the peculiar sponge and polyzoon fauna of Malabar is due to the agency either of wind or of marine currents may be denied with confidence, for it is a striking fact that most of the characteristic genera and subgenera of the Zone have resting reproductive bodies that are either fixed to solid objects or else are devoid of special apparatus to render them light. The former is the case as regards all species of *Corvospongilla* and all Indian and most other species of *Stratospongilla*, the gemmules of which not only are unusually heavy but also adhere firmly, while the statoblasts of *Fredericella* have no trace of the air-cells that render the free statoblasts of all other genera of phylactolæmatous polyzoa peculiarly light and therefore peculiarly liable to be transported by wind

* See Mem Geol Surv Ind xxxv (1), p 39 (1902)

A true geographical or geological explanation must therefore be sought for the relationship between the sponges and polyzoa of Malabar, of Africa, and of the Eastern countries—a relationship that is well known to exist as regards other groups of animals No more satisfactory explanation has as yet been put forward than that of a former land connection between Africa and the Malaysia through Malabar at a period (probably late Cretaceous) when the Western Ghats were much higher than they now are*.

There is little to be said as regards the distribution of the sponges, hydroids, and polyzoa of fresh water in other parts of India It may be noted, however, that the species known from the Punjab are all widely distributed Palæarctic forms, and that the genus *Stolella* is apparently confined to the Indo-Gangetic Plain Two species of sponge are peculiar to Lower Burma, one of them (*Corvospongilla burmanica*) representing the geographical alliance already discussed as regards the Malabar Zone, the other (*Tubella vesparioides*) closely related to a Malaysian species (*T vesparium* from Borneo) and perhaps representing the northern limit of the Malaysian element well known in the fauna of Lower Burma Of the sponges and polyzoa of Ceylon we know as yet too little to make it profitable to discuss their affinities. All that have as yet been discovered occur also in Peninsular India, nor do they afford any evidence of a connection with the Malabar Zone

The question of the geographical range of the sponges, hydroids, and polyzoa of brackish water may be considered briefly, for it is of importance in considering that of those which are confined to fresh water Some of these species from brackish water (e g, *Membranipora lacroixii*) are identical with others (e g, *Victorella bengalensis* and *Bowerbankia caudata* subsp. *bengalensis*) closely related to European forms Others again (e g, *Loxosomatoides colonialis* and *Sagartia schilleriana*) are known as yet from the Ganges delta only In our ignorance of the Indian representatives of the groups to which they belong, it is impossible to assert that their distribution is actually so restricted as it seems

* See Ortmann, "The Geographical Distribution of Freshwater Decapods and its bearing upon Ancient Geography," Proc Amer Phil. Soc xli, p 380, fig 6 (1902), also Suess, "The Face of the Earth" (English ed) i, p 416 (1904)

SOME SPECIAL LOCALITIES

In order to avoid constant repetition as regards the conditions that prevail at the places most frequently mentioned in this volume, a few details as regards them may be conveniently stated here

Lower Bengal

CALCUTTA is situated on the River Hughli at a point about 90 miles from the open sea The water of the river is practically fresh, but is strongly affected by the tides, it is always turbid and of a brownish colour The river, however, is not a good collecting ground for sponges, cœlenterates, and polyzoa, and none of the species described in this volume have been obtained from it. It is in the Calcutta "tanks" that most of my investigations have been made. These tanks are ponds, mostly of artificial origin, very numerous, of varying size but never very large or deep Most of them contain few solid objects to which sedentary organisms can fix themselves, and such ponds are of course poor in sponges and polyzoa Others, however, support a prolific growth of weeds such as *Pistia stratiotes*, *Lemna*, and *Limnanthemum*, and a few have brickwork or artificial stonework at their sides. In those parts of the town that approach the Salt Lakes (large lagoons and swamps of brackish water connected with the sea by the Mutlah River) the water of the ponds is slightly brackish and permits few plants except algæ to flourish Few of the bigger tanks ever dry up The best of the tanks from the sponge-collector's point of view, so far as I have been able to discover, is the one in the compound of the Indian Museum. It enjoys all the advantages of light and shade, solid supports, prolific aquatic vegetation, considerable depth, and the vicinity of human dwellings that seem to be favourable to the growth of sponges, no less than nine species of which, representing three genera and two subgenera, grow abundantly in it. *Hydra* also flourishes in this pond, but for some reasons there are few polyzoa The phylactolæmatous species of the latter group, however, are extraordinarily abundant in one of the tanks in the Zoological Gardens at Alipore In this tank, which unlike the Museum tank is directly connected with the river, no less than six species and varieties of the genus *Plumatella* have been found growing together on sticks, floating seeds, and water-plants Except *Hislopia*, which is common on *Vallisneria* in one tank on the

Maidan (opposite the Bengal Club), the ctenostomes of stagnant water are only found in the tanks near the Salt Lakes

PORT CANNING is situated on the Mutlah River about 30 miles from Calcutta and about 60 from the open sea The Mutlah is really a tidal creek rather than a river, in spite of the fact that it runs for a considerable number of miles, and its waters are distinctly brackish Water taken from the edge at Port Canning in March was found to contain 25 46 per thousand of saline residue The interesting feature of Port Canning, however, is from a zoological point of view not the Mutlah but certain ponds of brackish water now completely separated from it, except occasionally when the river is in flood, but communicating regularly with it in the memory of living persons These ponds, which were apparently not in existence in 1855, have on an average an area of about half an acre each, and were evidently formed by the excavation of earth for the construction of an embankment along the Mutlah They are very shallow and lie exposed to the sun. The salinity differs considerably in different ponds, although the fauna seems to be identical, the water of one pond was found to contain 22 88 per thousand of saline residue in May, 20 22 per thousand in March, and 12 13 in December A second pond in the neighbourhood of the first and apparently similar to it in every way contained only 9 82 per thousand in July, after the rains had broken The fauna of these ponds includes not only a freshwater sponge (*Spongilla alba* var *bengalensis*) but also many aquatic insects (*e. g*, larvæ of mosquitos and of *Chironomus* and several species of beetles and Rhynchota); while on the other hand essentially marine cœlenterates (*Irene ceylonensis*, etc) and worms (*e g*, the gephyrean *Physcosoma lurco* *) form a part of it, together with forms of intermediate habitat such as *Bowerbankia caudata* subsp *bengalensis*, *Victorella bengalensis*, and several fish and crustacea common in brackish water

Orissa

Orissa may be described in general terms as consisting of the coastal area of Bengal south of the Gangetic delta It extends in inland, however, for a considerable distance and includes hilly tracts. There is no geographical boundary between it and the

* I am indebted to Mr W. F Lanchester for the identification of this species.

north-eastern part of the Madras Presidency or the eastern part of the Central Provinces

CHILKA LAKE —This marine lake is a shallow lagoon measuring about 40 miles in length and 10 miles in breadth, and formed in geologically recent times by the growth of a narrow sand-bank across the mouth of a wide bay At its northern end it communicates with the sea by a narrow channel, and throughout its length it is strongly affected by the tides At its south end, which is actually situated in the Ganjam district of Madras, the water is distinctly brackish and is said to be nearly fresh at certain times of year At this end there are numerous small artificial pools of brackish water somewhat resembling those of Port Canning as regards their fauna.

SUR (or SAR) LAKE —A shallow, freshwater lake of very variable size situated a few miles north of Puri on the Orissa coast In origin it probably resembled the Chilka Lake, but it is now separated from the sea by about 3 miles of barren sand dunes, among which numerous little pools of rain-water are formed during the rains These dry up completely in winter, and even the lake itself is said sometimes almost to disappear, although when it is full it is several miles in length The fauna is essentially a freshwater one, but includes certain Mysidæ and other crustacea usually found in brackish water.

Bombay Presidency

BOMBAY —The town of Bombay, built on an island near the mainland, is situated close to swamps and creeks of brackish water not unlike those that surround Calcutta Its "tanks," however, differ from those of Calcutta in having rocky bottoms and, in many cases, in drying up completely in the hot weather Of the fauna of the swamps extremely little is known, but so far as the sponges and polyzoa of the tanks are concerned the work undertaken by Carter was probably exhaustive

IGATPURI —Igatpuri is situated at an altitude of about 2000 feet, 60 miles north-east of Bombay Above the town there is a lake of several square miles in area whence the water-supply of several stations in the neighbourhood is obtained The water is therefore kept free from contamination The bottom is composed of small stones and slopes gradually up at the edges During the dry weather its level sinks considerably Several interesting sponges

and polyzoa have been found in this lake, most of them also occurring in a small pond in the neighbourhood in which clothes are washed and the water is often full of soap-suds

Southern India

MADRAS —The city of Madras is built by the sea, straggling over a large area of the sandy soil characteristic of the greater part of the east coast of India In wet weather this soil retains many temporary pools of rain-water, and there are numerous permanent tanks of no great size in the neighbourhood of the town The so-called Cooum River, which flows through the town, is little more than a tidal creek, resembling the Mutlah River of Lower Bengal on a much smaller scale The sponges and polyzoa as yet found in the environs of Madras are identical with those found in the environs of Calcutta

BANGALORE —Bangalore (Mysore State) is situated near the centre of the Madras Presidency on a plateau about 3000 feet above sea-level The surrounding country is formed of laterite rock which decomposes readily and forms a fine reddish silt in the tanks These tanks are numerous, often of large size, and as a rule at least partly of artificial origin Their water supports few phanerogamic plants and is, as my friend Dr. Morris Travers informs me, remarkably free from salts in solution The sponge fauna of the neighbourhood of Bangalore appears to be intermediate between that of Madras and that of Travancore.

THE BACKWATERS OF COCHIN AND TRAVANCORE —The "backwaters" of Cochin and Travancore were originally a series of shallow lagoons stretching along the coast of the southern part of the west coast of India for a distance of considerably over a hundred miles They have now been joined together by means of canals and tunnels to form a tidal waterway, which communicates at many points directly with the sea The salinity of the water differs greatly at different places and in different seasons, and at some places there is an arrangement to keep out sea-water while the rice-fields are being irrigated The fauna is mainly marine, but in the less saline parts of the canals and lakes many freshwater species are found

Shasthancottah —There are two villages of this name, one situated on the backwater near Quilon (coast of Travancore), the

other about three miles inland on a large freshwater lake This lake, which does not communicate with the backwater, occupies a narrow winding rift several miles in length at a considerable depth below the surrounding country Its bottom is muddy and it contains few water-plants, although in some places the water-plants that do exist are matted together to form floating islands on which trees and bushes grow. The fauna, at any rate as regards mollusca and microscopic organisms, is remarkably poor, but two species of polyzoa (*Fredericella indica* and *Plumatella fruticosa*) and one of sponge (*Trochospongilla pennsylvanica*) grow in considerable abundance although not in great luxuriance

The Himalayas

BHIM TAL * is a lake situated at an altitude of 4500 feet in that part of the Western Himalayas known as Kumaon, near the plains. It has a superficial area of several square miles, and is deep in the middle Its bottom and banks are for the most part muddy Little is known of its fauna, but two polyzoa (*Plumatella allmani* and *Lophopodella carteri*) and the gemmules of two sponges (*Spongilla carteri* and *Ephydatia meyeni*) have been found in it

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NOMENCLATURE AND TERMINOLOGY

The subject of nomenclature may be considered under four heads —(I) the general terminology of the various kinds of groups of individuals into which organisms must be divided, (II) the general nomenclature of specimens belonging to particular categories, such as types, co-types, etc , (III) the nomenclature that depends on such questions as that of "priority", and (IV) the special terminology peculiar to the different groups The special terminology peculiar to the different groups is dealt with in the separate introductions to each of the three parts of this volume

(I.)

No group of animals offers greater difficulty than the sponges, hydroids, and polyzoa (and especially the freshwater representatives of these three groups) as regards the question "What is a species ?" and the kindred questions, "What is a subspecies ?" "What is a variety ?" and "What is a phase ?" Genera can

* The fauna of this lake and of others in the neighbourhood has recently been investigated by Mr S W Kemp See the addenda at the end of this volume —*June* 1911

often be left to look after themselves, but the specific and kindred questions are answered in so many different ways, if they are even considered, by different systematists, especially as regards the groups described in this volume, that I feel it necessary to state concisely my own answers to these questions, not for the guidance of other zoologists but merely to render intelligible the system of classification here adopted The following definitions should therefore be considered in estimating the value of "species," etc, referred to in the following pages

Species—A group of individuals differing in constant characters of a definite nature and of systematic * importance from all others in the same genus

Subspecies—An isolated or local race, the individuals of which differ from others included in the same species in characters that are constant but either somewhat indefinite or else of little systematic importance

Variety—A group of individuals not isolated geographically from others of the same species but nevertheless exhibiting slight, not altogether constant, or indefinite differences from the typical form of the species (*i e*, the form first described)

Phase—A peculiar form assumed by the individuals of a species which are exposed to peculiarities in environment and differ from normal individuals as a direct result

There are cases in which imperfection of information renders it difficult or impossible to distinguish between a variety and a subspecies In such cases it is best to call the form a variety, for this term does not imply any special knowledge as regards its distribution or the conditions in which it is found

I use the term "form" in a general sense of which the meaning or meanings are clear without explanation

(II)

The question of type specimens must be considered briefly There are two schools of systematists, those who assert that one specimen and one only must be the type of a species, and those who are willing to accept several specimens as types From the theoretical point of view it seems impossible to set up any one

* "What characters are of systematic importance?" is a question to which different answers must be given in the case of different groups

individual as the ideal type of a species, but those who possess collections or are in charge of museums prefer, with the natural instinct of the collector, to have a definite single type (of which no one else can possibly possess a duplicate) in their possession or care, and there is always the difficulty that a zoologist in describing a species, if he recognizes more than one type, may include as types specimens that really belong to more than one species These difficulties are met by some zoologists by the recognition of several specimens as paratypes, all of equal value, but this, after all, is merely a terminological means of escaping from the difficulty, calculated to salve the conscience of a collector who feels unwilling to give up the unique type of a species represented by other specimens in his collection The difficulty as regards the confounding of specimens of two or more species as the types of one can always be adjusted if the author who discovers the mistake re-describes one of the species under the original name and regards the specimen that agrees with his description as the type, at the same time describing a new species with another of the specimens as its type Personally I always desire to regard the whole material that forms the basis of an original description of a species as the type, but museum rules often render this impossible, and the best that can be done is to pick out one specimen that seems particularly characteristic and to call it the type, the rest of the material being termed co-types A peculiar difficulty arises, however, as regards many of the sponges, cœlenterates, and polyzoa, owing to the fact that they are often either compound animals, each specimen consisting of more than one individual, or are easily divisible into equivalent fragments If the single type theory were driven to its logical conclusion, it would be necessary to select one particular polyp in a hydroid colony, or even the part of a sponge that surrounded a particular osculum as the type of the species to which the hydroid or the sponge belonged Either by accident or by design specimens of Spongillidæ, especially if kept dry, are usually broken into several pieces There is, as a matter of fact, no reason to attribute the peculiarly sacrosanct nature of a type to one piece more than another In such cases the biggest piece may be called the type, while the smaller pieces may be designated by the term "schizotype"

The more precise definition of such terms as topotype, genotype, *et hujus generis omnis* is nowadays a science (or at any rate a form of technical industry) by itself and need not be discussed here

(III)

In 1908 an influential committee of British zoologists drew up a strenuous protest against the unearthing of obsolete zoological names (see 'Nature,' Aug 1908, p 395) To no group does this protest apply with greater force than to the three discussed in this volume It is difficult, however, to adopt any one work as a standard of nomenclature for the whole of any one of them. As regards the Spongillidæ it is impossible to accept any monograph earlier than Potts's "Fresh-Water Sponges' (P Ac Philad, 1887), for Bowerbank's and Carter's earlier monographs contained descriptions of comparatively few species Even Potts's monograph I have been unable to follow without divergence, for it seems to me necessary to recognize several genera and subgenera that he ignored The freshwater polyzoa, however, were dealt with in so comprehensive a manner by Allman in his "Fresh-Water Polyzoa" (London, 1856) that no difficulty is experienced in ignoring, so far as nomenclature is concerned, any earlier work on the group, while as regards other divisions of the polyzoa I have followed Hincks's "British Marine Polyzoa" (1880), so far as recent researches permit In most cases I have not attempted to work out an elaborate synonymy of species described earlier than the publication of the works just cited, for to do so is a mere waste of time in the case of animals that call for a most precise definition of species and genera and yet were often described, so far as they were known earlier than the dates in question, in quite general terms I have been confirmed in adopting this course by the fact that few of the types of the earlier species are now in existence, and that a large proportion of the Indian forms have only been described within the last few years.

MATERIAL

The descriptions in this volume are based on specimens in the collection of the Indian Museum, the Trustees of which, by the liberal manner in which they have permitted me to travel in India and Burma on behalf of the Museum, have made it possible not only to obtain material for study and exchange but also to observe the different species in their natural environment This does not mean to say that specimens from other collections have been ignored, for many institutions and individuals have met us generously in the matter of gifts and exchanges, and our collection

now includes specimens of all the Indian forms, named in nearly all cases by the author of the species, except in those of species described long ago of which no authentic original specimens can now be traced. Pieces of the types of all of the Indian Spongillidæ described by Carter have been obtained from the British Museum through the kind offices of Mr R. Kirkpatrick The Smithsonian Institution has sent us from the collection of the United States National Museum specimens named by Potts, and the Berlin Museum specimens named by Weltner, while to the Imperial Academy of Sciences of St Petersburg we owe many unnamed but interesting sponges Dr. K. Kraepelin and Dr. W. Michaelsen have presented us with specimens of most of the species and varieties of freshwater polyzoa described by the former in his great monograph and elsewhere We owe to Dr S F Harmer, formerly of the Cambridge University Museum and now Keeper in Zoology at the British Museum, to Professor Max Weber of Amsterdam, Professor Oka of Tokyo, and several other zoologists much valuable material I would specially mention the exquisite preparations presented by Mr. C Rousselet Several naturalists in India have also done good service to the Museum by presenting specimens of the three groups described in this volume, especially Major H. J. Walton, I.M S, Major J Stephenson, I M S, Dr. J R. Henderson and Mr. G. Matthai of Madras, and Mr. R Shunkara Narayana Pillay of Trivandrum

The following list shows where the types of the various species, subspecies, and varieties are preserved, so far as it has been possible to trace them I have included in this list the names of all species that have been found in stagnant water, whether fresh or brackish, but those of species not yet found in fresh water are enclosed in square brackets

Indian Spongillidae

Name	Type in Coll.	Material Examined
Spongilla lacustris subsp. *reticulata*	Ind. Mus.	Type
Spongilla proliferens	" "	"
Spongilla alba	Brit. and Ind. Mus.	Schizotype
[*Spongilla alba* var. *bengalensis*]	Ind. Mus.	Type
Spongilla alba var. *cerebellata*	Brit. Mus.	Specimens compared with type
Spongilla cinerea	Brit. and Ind. Mus.	Schizotype
[*Spongilla travancorica*]	Ind. Mus.	Type
Spongilla hemephydatia	" "	"
Spongilla crateriformis	U. S. Nat. Mus.	Co-type
Spongilla carteri	Brit. and Ind. Mus.	Schizotype
Spongilla carteri var. *mollis*	Ind. Mus.	Type
Spongilla carteri var. *cava*	" "	"
Spongilla carteri var. *lobosa*	" "	"
Spongilla fragilis subsp. *calcuttana*	" "	"
Spongilla fragilis subsp. *decipiens*	Amsterdam Mus.	Co-type
Spongilla gemina	Ind. Mus.	Type
Spongilla crassissima	" "	"
Spongilla crassissima var. *crassior*	" "	"
Spongilla bombayensis	Brit. and Ind. Mus.	Schizotype
Spongilla indica	Ind. Mus.	Type
Spongilla ultima	" "	"
Pectispongilla aurea	" "	"
Ephydatia meyeni	Brit. and Ind. Mus.	Schizotype
Dosilia plumosa	" " " "	"
Trochospongilla latouchiana	Ind. Mus.	Type
Trochospongilla phillottiana	" "	"
Trochospongilla pennsylvanica	U. S. Nat. Mus.	Co-type
Tubella vesparioides	Ind. Mus.	Type
Corvospongilla burmanica	Brit. and Ind. Mus.	Schizotype
Corvospongilla lapidosa	Ind. Mus.	Type

Indian Cœlenterates of Stagnant Water

Hydrozoa		
Hydra oligactis	Not in existence	
Hydra vulgaris	" "	
[*Syncoryne filamentata*]	Ind. Mus.	Type
[*Bimeria vestita*]	? Not in existence	
[*Irene ceylonensis*]	Hydroid in Ind. Mus., Medusa in Brit. Mus.	Hydroid type
Actiniaria		
[*Sagartia schilleriana*]	Ind. Mus.	Types
[*Sagartia schilleriana* subsp. *exul*]	" "	"

INDIAN POLYZOA OF STAGNANT WATER.

NAME	TYPE IN COLL	MATERIAL EXAMINED
ENTOPROCTA		
[*Loxosomatoides colonialis*]	Ind Mus	Types
ECTOPROCTA CHEILOSTOMATA		
[*Membranipora lacroixii*]	? Paris Mus	
[*Membranipora bengalensis*]	Ind Mus	Types
ECTOPROCTA STENOSTOMATA		
[*Bowerbankia caudata* subsp *bengalensis*]	Ind Mus	Types
Victorella bengalensis	" "	"
Hislopia lacustris	? Not in existence	
Hislopia lacustris subsp *moniliformis*	Ind Mus	"
ECTOPROCTA PHYLACTOLÆMATA		
Fredericella indica	Ind Mus	Type
Plumatella fruticosa	Not in existence	
Plumatella diffusa	?Philadelphia Acad †	
Plumatella allmani	Not in existence	
Plumatella emarginata	" "	
Plumatella javanica	Hamburg and Ind Mus	One of the types
Plumatella tanganyikæ	Brit and Ind Mus	One of the types
Stolella indica .	Ind Mus	Type
Lophopodella carteri	Brit Mus	"
Lophopodella carteri var *himalayana*	Ind Mus	"
Pectinatella burmanica	Ind Mus	"

† I have failed to obtain from the Philadelphia Academy of Science a statement that the type of this species is still in existence

The literature dealing with the various groups described in the volume is discussed in the introductions to the three parts. Throughout the volume I have, so far as possible, referred to works that can be consulted in Calcutta in the libraries of the Indian Museum, the Geological Survey of India, or the Asiatic Society of Bengal The names of works that are not to be found in India are marked with a * The rarity with which this mark occurs says much for the fortunate position in which zoologists stationed in Calcutta find themselves as regards zoological literature, for I do not think that anything essential has been omitted.

It remains for me to express my gratitude to those who have assisted me in the preparation of this volume The names of

those who have contributed specimens for examination have already been mentioned I have to thank the Trustees of the Indian Museum not only for their liberal interpretation of my duties as an officer of the Museum but also for the use of all the drawings and photographs and some of the blocks from which this volume is illustrated Several of the latter have already been used in the "Records of the Indian Museum" From the Editor of the "Fauna" I have received valuable suggestions, and I am indebted to Dr Weltner of the Berlin Museum for no less valuable references to literature Mr F H Gravely, Assistant Superintendent in the Indian Museum, has saved me from several errors by his criticism

The majority of the figures have been drawn by the draftsmen of the Indian Museum, Babu Abhoya Charan Chowdhary, and of the Marine Survey of India, Babu Shib Chandra Mondul, to both of whom I am much indebted for their accuracy of delineation

No work dealing with the sponges of India would be complete without a tribute to the memory of H J Carter, pioneer in the East of the study of lower invertebrates, whose work persists as a guide and an encouragement to all of us who are of the opinion that biological research on Indian animals can only be undertaken in India, and that even systematic zoological work can be carried out in that country with success I can only hope that this, the first volume in the official Fauna of the Indian Empire to be written entirely in India, may prove not unworthy of his example

Indian Museum,
Calcutta

Oct 23rd, 1910

PART I.

FRESHWATER SPONGES

(SPONGILLIDÆ)

INTRODUCTION TO PART I.

I.

THE PHYLUM PORIFERA

THE phylum Porifera or Spongiæ includes the simplest of the Metazoa or multicellular animals From the compound Protozoa its members are distinguished by the fact that the cells of which they are composed exhibit considerable differentiation both in structure and in function, and are associated together in a definite manner, although they are not combined to form organs and systems of organs as in the higher Metazoa Digestion, for instance, is performed in the sponges entirely by individual cells, into the substance of which the food is taken, and the products of digestion are handed on to other cells without the intervention of an alimentary canal or a vascular system, while there is no structure in any way comparable to the nervous system of more highly organized animals

The simplest form of sponge, which is known as an olynthus, is a hollow vase-like body fixed at one end to some solid object, and with an opening called the osculum at the other The walls are perforated by small holes, the pores, from which the name Porifera is derived

Externally the surface is protected by a delicate membrane formed of flattened cells and pierced by the pores, while the interior of the vase is covered with curious cells characteristic of the sponges, and known as choanocytes or collar-cells They consist of minute oval or pear-shaped bodies, one end of which is provided with a rim or collar of apparently structureless membrane, while a flagellum or whip-like lash projects from the centre of the surface surrounded by the collar These collar-cells are practically identical with those of which the Protozoa known as Choanoflagellata consist, but it is only in the sponges* that they are found constantly associated with other cells unlike themselves

In addition to the collar-cells, which form what is called the gastral layer, and the external membrane (the derma or dermal

* Except in "*Proterospongia*," an organism of doubtful affinities but not a sponge It consists of a mass of jelly containing ordinary cells, with collar-cells *outside*

membrane), the sponge contains cells of various kinds embedded in a structureless gelatinous substance, through which they have the power of free movement, Most of these cells have also the power of changing their form in an "amœboid" manner, that is to say, by projecting and withdrawing from their margin mobile processes of a more or less finger-like form, but unstable in shape or direction The protoplasm of which some of the cells are formed is granular, while that of others is clear and translucent Some cells, which (for the time being at any rate) do not exhibit amœboid movements, are glandular in function, while others again give rise in various ways to the bodies by means of which the sponge reproduces its kind There is evidence, however, that any one kind of cell, even those of the membrane and the gastral layer, can change its function and its form in case of necessity

Most sponges possess a supporting framework or skeleton In some it is formed entirely of a horny substance called spongin (as in the bath-sponge), in others it consists of spicules of inorganic matter (either calcareous or siliceous) secreted by special cells, or of such spicules bound together by spongin Extraneous objects, such as sand-grains, are frequently included in the skeleton The spongin is secreted like the spicules by special cells, but its chemical structure is much more complicated than that of the spicules, and it is not secreted (at any rate in most cases) in such a way as to form bodies of a definite shape In the so-called horny sponges it resembles the chitin in which insects and other arthropods are clothed.

In no adult sponge do the collar-cells completely cover the whole of the internal surface, the olynthus being a larval form, and by no means a common larval form It is only found in certain sponges with calcareous spicules As the structure of the sponge becomes more complicated the collar-cells are tucked away into special pockets or chambers known as ciliated chambers, and finally the approach to these chambers, both from the external surface and from the inner or gastral cavity, takes the form of narrow tubes or canals instead of mere pores With further complexity the simple internal cavity tends to disappear, and the sponge proliferates in such a way that more than one osculum is formed In the class Demospongiæ, to which the sponges described in this volume belong, the whole system is extremely complicated

The skeleton of sponges, when it is not composed wholly of spongin, consists of, or at any rate contains, spicules that have a definite chemical composition and definite shapes in accordance with the class, order, family, genus, and species of the sponge. Formerly sponges were separated into calcareous, siliceous, and horny sponges by the nature of their skeleton, and although the system of classification now adopted has developed into a much more complex one and a few sponges are known that have both calcareous and siliceous spicules, the question whether the spicules

are formed of salts of lime or of silica (strictly speaking of opal) is very important. All Demospongiæ that have spicules at all have them of the latter substance, and the grade Monaxonida, in which the freshwater sponges constitute the family Spongillidæ, is characterized by the possession of spicules that have typically the form of a needle pointed at both ends. Although spicules of this simple form may be absent in species that belong to the grade, the larger spicules, which are called megascleres, have not normally more than one main axis and are always more or less rod-like in outline. They are usually arranged so as to form a reticulate skeleton. Frequently, however, the megascleres or skeleton-spicules are not the only spicules present, for we find smaller spicules (microscleres) of one or more kinds lying loose in the substance of the sponge and in the external membrane, or, in the Spongillidæ only, forming a special armature for the reproductive bodies known as gemmules.

All sponges obtain their food in the same way, namely by means of the currents of water set up by the flagella of the collar-cells. These flagella, although apparently there is little concerted action among them, cause by their rapid movements changes of pressure in the water contained in the cavities of the sponge. The water from outside therefore flows in at the pores and finally makes its way out of the oscula. With the water minute particles of organic matter are brought into the sponge, the collar-cells of which, and probably other cells, have the power of selecting and engulfing suitable particles. Inside the cells these particles undergo certain chemical changes, and are at least partially digested. The resulting substances are then handed on directly to other cells, or, as some assert, are discharged into the common jelly, whence they are taken up by other cells.

Sponges reproduce their kind in more ways than one, *viz.*, by means of eggs (which are fertilized as in other animals by spermatozoa), by means of buds, and by means of the peculiar bodies called gemmules the structure and origin of which is discussed below (p. 42). They are of great importance in the classification of the Spongillidæ. Sponges can also be propagated artificially by means of fission, and it is probable that this method of reproduction occurs accidentally, if not normally, in natural circumstances.

General Structure of the Spongillidæ

It would be impracticable in this introduction to give a full account of the structure of the Spongillidæ, which in some respects is still imperfectly known. Students who desire further information should consult Professor Minchin's account of the sponges in Lankester's 'Treatise on Zoology,' part ii, or, if a less technical description is desired, Miss Sollas's contribution to the 'Cambridge Natural History,' vol. i, in which special attention is paid to *Spongilla*.

The diagram reproduced in fig 1 gives a schematic view of a vertical section through a living freshwater sponge Although it represents the structure of the organism as being very much simpler than is actually the case, and entirely omits the skeleton, it will be found useful as indicating the main features of the anatomy

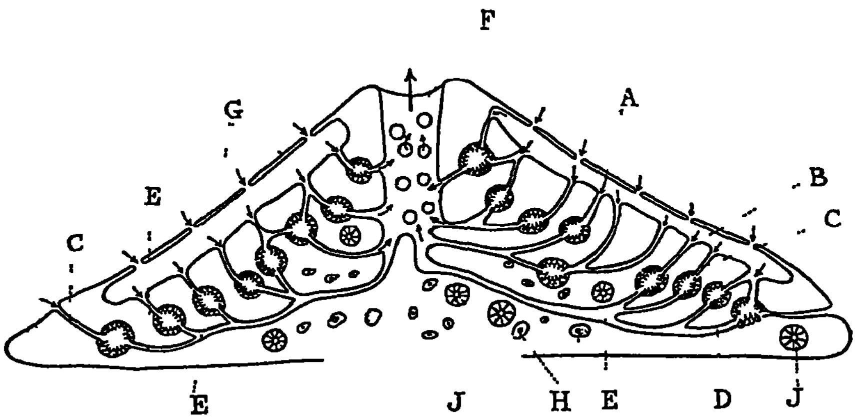

Fig 1 —Diagram of a vertical section through a freshwater sponge (*modified from Kukenthal*)

A=pores, B=subdermal cavity, C=inhalent canal, D=ciliated chamber, E=exhalent canal, F=osculum, G=dermal membrane, H=eggs, J=gemmule

It will be noted that the diagram represents an individual with a single osculum or exhalent aperture As a rule adult Demospongiæ have several or many oscula, but even in the Spongillidæ sponges occur in which there is only one New oscula are formed by a kind of proliferation that renders the structure still more complex than it is when only one exhalent aperture is present

The little arrows in the figure indicate the direction of the currents of water that pass through the sponge It enters through small holes in the derma into a subdermal cavity, which separates the membrane from the bulk of the sponge This space differs greatly in extent in different species From the subdermal space the water is forced by the action of the flagella into narrow tubular canals that carry it into the ciliated chambers Thence it passes into other canals, which communicate with what remains of the central cavity, and so out of the oscula

The ciliated chambers are very minute, and the collar-cells excessively so It is very difficult to examine them owing to their small size and delicate structure Fig 2 D represents a collar-cell of a sponge seen under a very high power of the microscope in ideal conditions

The nature of the inhalent apertures in the external membrane has been much discussed as regards the Demospongiæ, but the truth seems to be that their structure differs considerably even in

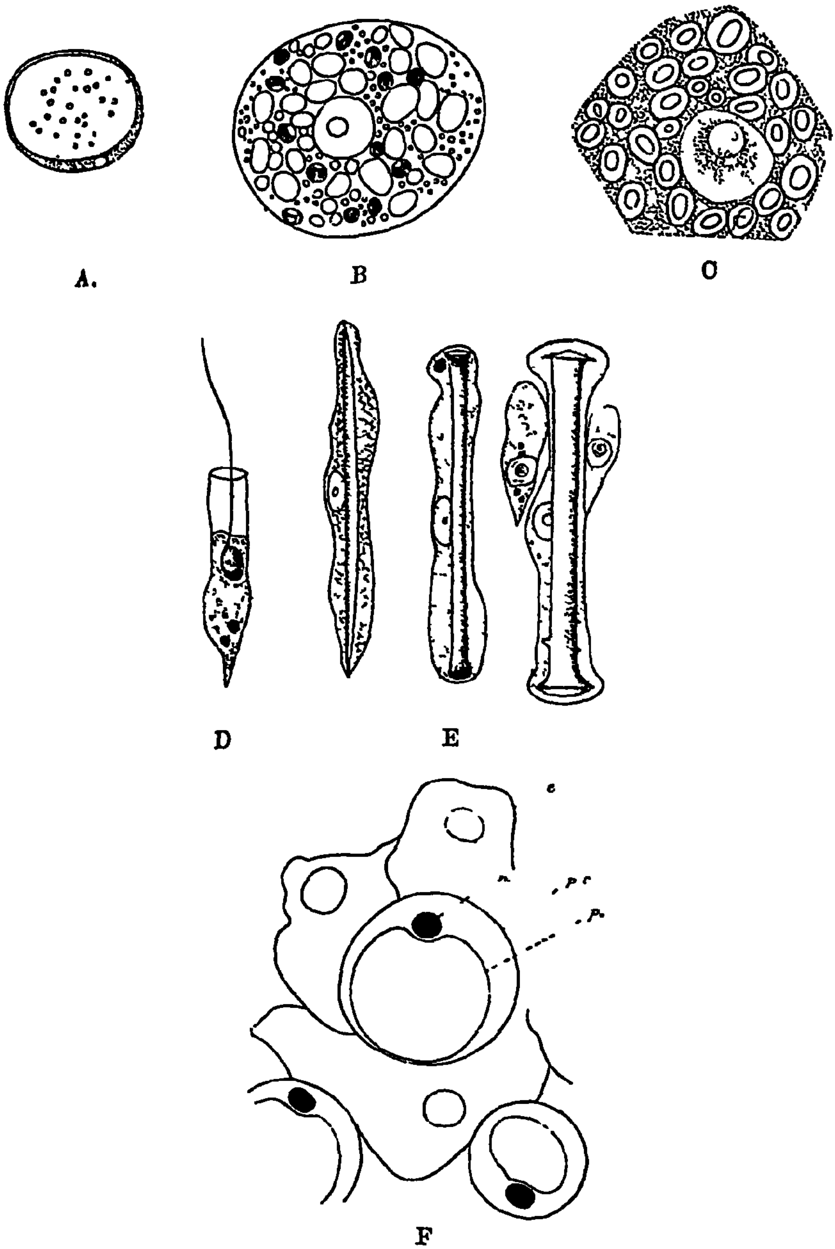

Fig 2 —Sponge cells

A=bubble-cells of *Ephydatia mulleri*, × 350 (*after Weltner*) B=gemmule-cell of *Spongilla lacustris* containing green corpuscles (shaded dark), × 800 (*after Weltner*) C=gemmule-cell of *Ephydatia blembingia* showing "tabloids" of food-material, × 1150 (*after Evans*) D=collar-cell of *Esperella ægagropila* × 1600 (*after Vosmaer and Pekelharing*) E=three stages in the development of a gemmule-spicule of *E blembingia* (*after Evans*), × 665 F=outline of porocytes of *S proliferens*, × ca 1290 *e*=dermal cell, *n*=nucleus, *p*=pore, *p c* =pore-cell

closely allied species At any rate this is the case as regards the Indian *Spongillæ* In all species the membrane is composed of flattened cells of irregular shape fitted together like the pieces of a puzzle-picture In some species (e g, *Spongilla carteri*) the *apertures in the membrane consist merely of spaces between* adjacent cells, which may be a little more crowded together than is usual But in others (e g, *Spongilla proliferens* and *Spongilla crassissima*) in which the pores are extremely small, each pore normally pierces the middle of a flat, ring-shaped cell or porocyte Occasionally, however, a pore may be found that is enclosed by two narrow, crescent-shaped cells joined together at their tips to form a ring The porocytes of sponges like *Spongilla carteri* are probably not actually missing, but instead of being in the external membrane are situated below the derma at the external entrance to the canals that carry water to the flagellated chambers or even at the entrance to the chambers themselves * Some authors object on theoretical grounds to the statement that porocytes exist in the Demospongia, and it is possible that these cells have in this grade neither the same origin as, nor a precisely similar function to, the porocytes of other sponges When they occur in the dermal membrane no great difficulty is experienced in seeing them under a sufficiently high power of the microscope, if the material is well preserved and mounted and stained in a suitable manner † In most sponges the porocytes can contract in such a way that the aperture in their centre is practically closed, but this power appears to be possessed by the porocytes of *Spongilla* only to a very limited extent, although they closely resemble the porocytes of other sponges in appearance

The external membrane in many Spongillidæ is prolonged round and above the oscula so as to form an oscular collar This structure is highly contractile, but cannot close together As a rule it is much more conspicuous in living sponges than in preserved specimens

It is not necessary to deal here with most of the cells that occur in the parenchyma or gelatinous part of the sponge A full list of the kinds that are found is given by Dr Weltner in his "Spongillidenstudien, V," p 276 (Arch Naturg Berlin, lxxiii (1), 1907) One kind must, however, be briefly noticed as being of some systematic importance, namely the "bubble-cells" (fig 2 A) that are characteristic of some species of *Ephydatia* and other genera These cells are comparatively large, spherical in form, each of them contains a globule of liquid which not only occupies the greater part of the cell, but forces the protoplasm to assume the form of a delicate film lining the cell-wall and covering the

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* *Cf* Weltner, "Spongillidenstudien, V," Arch Naturg Berlin, lxxiii (1), p 273 (1907)

† It is difficult to see any trace of them in thin microtome sections A fragment of the membrane must be mounted whole

globule In optical section "bubble-cells" have a certain resemblance to porocytes, but the cell is of course imperforate and not flattened.

SKELETON AND SPICULES.

In the Spongillidæ the spicules and the skeleton are more important as regards the recognition of genera and species than

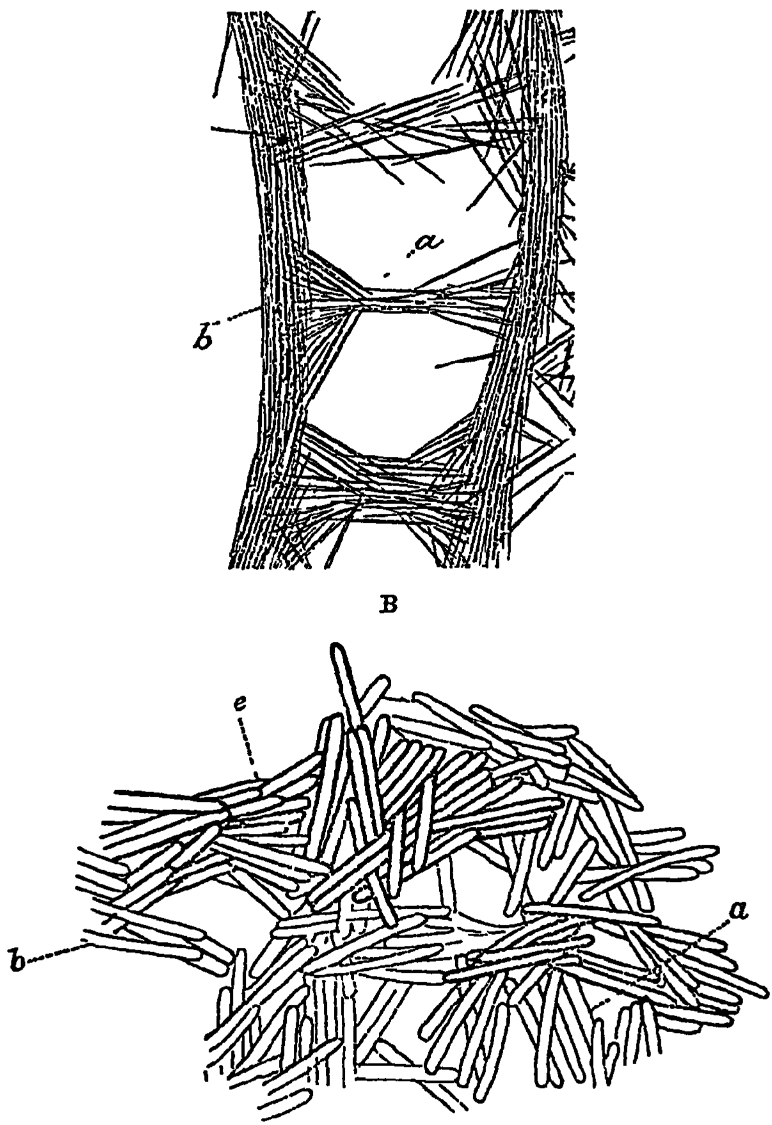

Fig 3 —Radial sections of fragments of the skeletons of *Spongillæ*

A, *S crassissima* var *crassior* (from Rajshahi), B, *S carteri* (from Calcutta), *a*=transverse, *b*=radiating fibres, *e*=external surface of the sponge

the soft parts. The skeleton is usually reticulate, but sometimes consists of a mass of spicules almost without arrangement. The amount of spongin present is also different in different species The spicules in a reticulate skeleton are arranged so as to form fibres of two kinds—radiating fibres, which radiate outwards from the centre of the sponge and frequently penetrate the external membrane, and transverse fibres, which run across from one radiating fibre to another The fibres are composed of relatively large spicules (megascleres) arranged parallel to one another, overlapping at the ends, and bound together by means of a more or less profuse secretion of spongin In some species they are actually enclosed in a sheath of this substance The radiating fibres are usually more distinct and stouter than the transverse ones, which are often represented by single spicules but are sometimes splayed out at the ends so as to assume in outline the form of an hour-glass (fig 3 B) The radiating fibres frequently raise up the membrane at their free extremities just as a tent-pole does a tent

Normal spicules of the skeleton are always rod-like or needle-like and either blunt or pointed at both ends, they are either smooth, granular, or covered with small spines Sometimes spicules of the same type form a more or less irregular transverse network at the base or on the surface of the sponge

From the systematist's point of view, the structure of the free spicules found scattered in the substance and membrane of the sponge, and especially of those that form the armature of the gemmules, is of more importance than that of the skeleton-spicules Free spicules are absent in many species, when

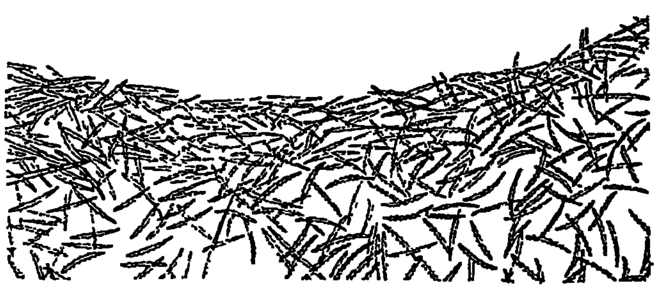

Fig 4 —Part of an oscular collar of *Spongilla lacustris* subsp *reticulata*, showing arrangement of microscleres in the dermis (magnified)

present they are usually needle-like and pointed at the tips In a few species, however, they are of variable or irregular form, or consist of several or many shafts meeting in a common central nodule In one genus (*Corvospongilla*) they resemble a double grappling-iron in form, having a circle of strongly recurved hooks at both ends. The free microscleres, or flesh-spicules as they are often called, are either smooth, granular, or spiny

Gemmule-spicules, which form a characteristic feature of the Spongillidæ, are very seldom absent when the gemmules are mature They are of the greatest importance in distinguishing the genera In their simplest form they closely resemble the free microscleres, but in several genera they bear, either at or near one end or at or near both ends, transverse disks which are either smooth or indented round the edge In one genus (*Pectispongilla*) they are provided at both ends not with disks but with vertically parallel rows of spines resembling combs in appearance.

The simpler spicules of the Spongillidæ are formed in single cells (see fig 2 E), but those of more complicated shape are produced by several cells acting in concert. Each spicule, although it is formed mainly of hydrated silica (opal), contains a slender organic filament running along its main axis inside the silica This filament, or rather the tube in which it is contained, is often quite conspicuous, and in some species (e g, *Spongilla crassissima*) its termination is marked at both ends of the megasclere by a minute conical protuberance in the silica

Unless sponges are alchemists and can transmute one element into another, the material of which the spicules are made must ultimately come from the water in which the sponges live, or the rocks or other bodies to or near which they are attached. The amount of water that must pass through a large specimen of such a sponge as *Spongilla carteri* in order that it may obtain materials for its skeleton must be enormous, for silica is an insoluble substance I have noticed, however, that this sponge is particularly abundant and grows with special luxuriance in ponds in which clothes are washed with soap, and my friend Mr. G. H. Tipper has suggested to me that possibly the alkali contained in the soapsuds may assist the sponge in dissolving out the silica contained in the mud at the bottom of the ponds. The question of how the mineral matter of the skeleton is obtained is, however, one about which we know nothing definite.

The spongin that binds the skeleton-spicules together takes the form of a colourless or yellowish transparent membrane, which is often practically invisible. When very abundant it sometimes extends across the nodes of the skeleton as a delicate veil In some sponges it also forms a basal membrane in contact with the object to which the sponge is attached, and in some such cases the spongin of the radiating fibres is in direct continuity with that of the basal membrane.

Colour and Odour.

Most freshwater sponges have a bad odour, which is more marked in some species than in others. This odour is not peculiar to the Spongillidæ, for it is practically identical with that given out by the common marine sponge *Halichondria panicea*

Its function is probably protective, but how it is produced we do not know

The coloration of freshwater sponges is usually dull and uniform, but *Pectispongilla aurea* is of the brilliant yellow indicated by its name, while many species are of the bright green shade characteristic of chlorophyll, the colouring matter of the leaves of plants Many species are brown or grey, and some are almost white

These colours are due to one of three causes, or to a combination of more than one of them, viz —(1) the inhalation of solid inorganic particles, which are engulfed by the cells, (2) the presence in the cells of coloured substances, solid or liquid, produced by the vital activities of the sponge, and (3) the presence in the cells of peculiar organized living bodies known as "green corpuscles"

Sponges living in muddy water are often nearly black. This is because the cells of their parenchyma are gorged with very minute solid particles of silt If a sponge of the kind is kept in clean water for a few days, it often becomes almost white An interesting experiment is easily performed to illustrate the absorption and final elimination of solid colouring matter by placing a living sponge (small specimens of *Spongilla carteri* are suitable) in a glass of clean water, and sprinkling finely powdered carmine in the water In a few hours the sponge will be of a bright pink colour, but if only a little carmine is used at first and no more added, it will regain its normal greyish hue in a few days

The colouring matter produced by the sponge itself is of two kinds—pigment, which is probably a waste product, and the substances produced directly by the ingestion of food or in the process of its digestion When pigment is produced it takes the form of minute granules lying in the cells of the parenchyma, the dermal membrane being as a rule colourless Very little is known about the pigments of freshwater sponges, and even less about the direct products of metabolism It is apparently the latter, however, that give many otherwise colourless sponges a slight pinkish or yellowish tinge directly due to the presence in cells of the parenchyma of minute liquid globules In one form of *Spongilla carteri* these globules turn of a dark brown colour if treated with alcohol The brilliant colour of *Pectispongilla aurea* is due not to solid granules but to a liquid or semi-liquid substance contained in the cells

The green corpuscles of the Spongillidæ are not present in all species There is every reason to think that they represent a stage in the life-history of an alga, and that they enter the sponge in an active condition (see p 49)

A fourth cause for the coloration of freshwater sponges may be noted briefly It is not a normal one, but occurs commonly in certain forms (e g , *Spongilla alba* var *bengalensis*) This cause is the growth in the canals and substance of the sponge of parasitic

algæ, which turn the whole organism of a dull green colour They do not do so, however, until they have reduced it to a dying state The commonest parasite of the kind is a filamentous species particularly common in brackish water in the Ganges delta

External Form and Consistency

The external form of sponges is very variable, but each species, subspecies, or variety of the Spongillidæ has normally a characteristic appearance The European race of *Spongilla lacustris*, for example, consists in favourable circumstances of a flattened basal part from which long cylindrical branches grow out; while

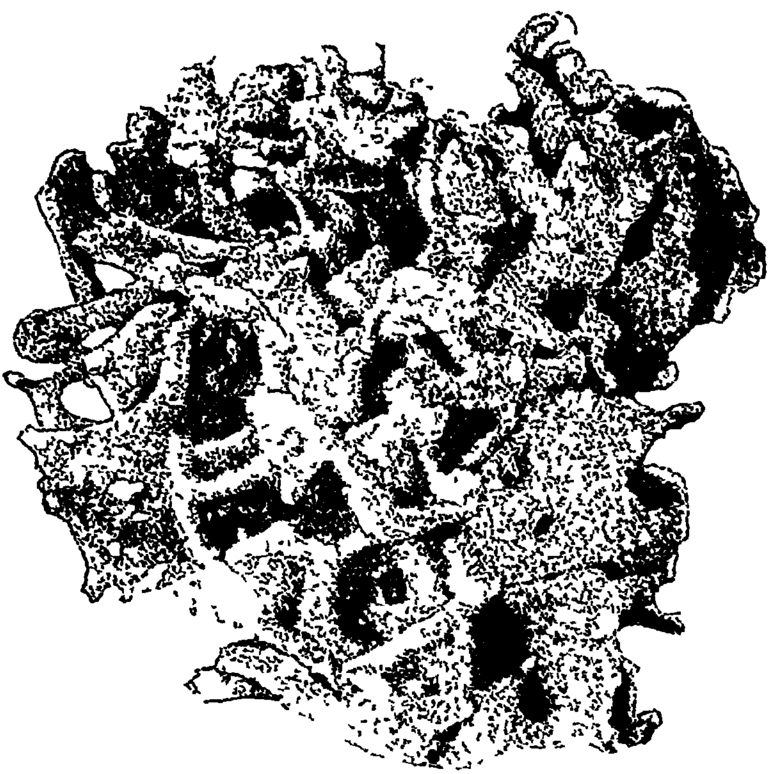

Fig 5—Part of a type-specimen of *Spongilla lacustris* subsp *reticulata* (nat. size)

in the Indian race of the species these branches are flattened instead of being cylindrical, and anastomose freely The structure of the branches is identical with that of the basal part. Many other species (for instance, *Spongilla bombayensis* and *S ultima*) never produce branches but always consist of lichenoid

or cushion-shaped masses The appearance of *Spongilla crateriformis*, when it is growing on a flattened surface which allows it to develop its natural form, is very characteristic, for it consists of little flattened masses that seem to be running out towards one another, just as though the sponge had been dropped, spoonful by spoonful, in a viscous condition from a teaspoon Some species, such as *Trochospongilla phillottiana*, cover large areas with a thin film of uniform thickness, while others (e g, *Spongilla alba* and *Ephydatia meyeni*) consist of irregular masses, the surface of which bears numerous irregular ridges or conical, subquadrate, or digitate processes In a few forms (e g, *Corvospongilla burmanica*) the surface is covered with small turret-like projections of considerable regularity, and some (e g, *Spongilla crassissima*) naturally assume a spherical or oval shape with an absolutely smooth surface

The production of long branches is apparently rare in tropical freshwater sponges

The form of the oscula is characteristic in many cases. No other Indian species has them so large, or with such well-defined margins as *Spongilla carteri* (Pl II, fig 1) In many species (Pl II, fig 3) they have a stellate appearance owing to the fact that grooves in the substance of the sponge radiate round them

Fig. 6.—Radial section through part of a dried sponge of *Spongilla crassissima* (from Calcutta), × 5

beneath the external membrane In other species they are quite inconspicuous and very small

Spongillidæ differ greatly in consistency. *Spongilla crassissima* and *Corvospongilla lapidosa* are almost stony, although the former is extremely light, more like pumice than true stone Other species (e. g, *Trochospongilla latouchiana*) are hard but brittle, while others again are soft and easily compressed, as *Spongilla lacustris*, the variety *mollis* of *S carteri*, and *S crateriformis* The consistency of a sponge depends on two factors—the number of spicules present, and the amount of spongin. In *Corvospongilla lapidosa* the number of spicules is very large indeed They are not arranged so as to form a reticulate skeleton but interlock in

all directions, and there is hardly any spongin associated with them. In *Spongilla crassissima*, on the other hand, the number of spicules although large is not unusually so, but they form a very definitely reticulate skeleton, and are bound together by an unusually profuse secretion of spongin. In *S carteri* var. *mollis* both spicules and spongin are reduced to a minimum, and the parenchyma is relatively more bulky than usual.

VARIATION.

Sponges are very variable organisms, and even a slight change in the environment of the freshwater species often produces a considerable change in form and structure Some species vary in accordance with the season, and others without apparent cause Not only have many given rise to subspecies and "varieties" that possess a certain stability, but most if not all are liable to smaller changes that apparently affect both the individual and the breed, at any rate for a period.

(a) *Seasonal Variation*

Weltner has shown in a recent paper (Arch. Natg Berlin, lxxiii (1), p 276, 1907) that in Europe those individuals of *Ephydatia* which are found (exceptionally) in an active condition in winter differ considerably both as regards the number of their cells and their anatomy from those found in summer In Calcutta the majority of the individuals of *Spongilla carteri* that are found in summer have their external surface unusually smooth and rounded, and contain in their parenchyma numerous cells the protoplasm of which is gorged with liquid These cells give the whole sponge a faint pinkish tinge during life, but if it is plunged in spirit, both the liquid in the cells and the spirit turn rapidly of a dark brown colour. Specimens of *Spongilla crateriformis* taken in a certain tank in Calcutta during the cold weather had the majority of the skeleton-spicules blunt, while the extremities of the gemmule-spicules were distinctly differentiated Specimens of the same species taken from the same tank in July had the skeleton-spicules pointed, while the extremities of the gemmule-spicules were much less clearly differentiated I have been unable to confirm this by observations made on sponges from other tanks, but it would certainly suggest that at any rate the breed of sponges in the tank first investigated was liable to seasonal variation.

(b) *Variation due directly to Environment*

The characteristic external form of freshwater sponges is liable in most cases to be altered as a direct result of changes in the

environment The following are two characteristic instances of this phenomenon

Certain shrubs with slender stems grow in the water at the edge of Igatpuri Lake The stems of these shrubs support many large examples of *Spongilla carteri*, which are kept in almost constant motion owing to the action of the wind on those parts of the shrubs that are not under water The surface of the sponges is so affected by the currents of water thus set up against it that it is covered with deep grooves and high irregular ridges like cocks-combs Less than a hundred yards from the lake there is a small pond in which *Spongilla carteri* is also abundant Here it grows on stones at the bottom and has the characteristic and almost smooth form of the species.

My second instance also refers in part to Igatpuri Lake *Corvo-spongilla lapidosa* is common in the lake on the lower surface of stones, and also occurs at Nasik, about thirty miles away, on the walls of a conduit of dirty water In the latter situation it has the form of large sheets of a blackish colour, with the surface corrugated and the oscula inconspicuous, while in the clear waters of the lake it is of a pale yellowish colour, occurs in small lichenoid patches, and has its oscula rendered conspicuous, in spite of their minute size, by being raised on little conical eminences in such a way that they resemble the craters of volcanoes in miniature

Both the European and the Indian races of *Spongilla lacustris* fail to develop branches if growing in unfavourable conditions In specimens obtained from the River Spree near Berlin these structures are sometimes many inches in length, while in mature specimens taken under stones in Loch Baa in the Island of Mull the whole organism consisted of a minute cushion-shaped mass less than an inch in diameter, and was also deficient in spicules Both these breeds belong to the same species, and probably differ as a direct result of differences in environment.

(c) *Variation without apparent cause*

Plate I in this volume illustrates an excellent example of variation in external form to which it is impossible to assign a cause with any degree of confidence The three specimens figured were all taken in the same pond, and at the same season, but in different years It is possible that the change in form, which was not peculiar to a few individuals but to all those in several adjacent ponds, was due to a difference in the salinity of the water brought about by a more or less abundant rainfall; but of this I have been able to obtain no evidence in succeeding years

Many Spongillidæ vary without apparent cause as regards the shape, size, and proportions of their spicules This is the case as regards most species of *Eunapius* and *Ephydatia*, and is a fact to which careful consideration has to be given in separating the species.

Nutrition.

Very little is known about the natural food of freshwater sponges, except that it must be of an organic nature and must be either in a very finely divided or in a liquid condition. The cells of the sponge seem to have the power of selecting suitable food from the water that flows past them, and it is known that they will absorb milk. The fact that they engulf minute particles of silt does not prove that they lack the power of selection, for extraneous matter is taken up by them not only as food but in order that it may be eliminated. Silt would soon block up the canals and so put a stop to the vital activity of the sponge, if it were not got rid of, and presumably it is only taken into the cells in order that they may pass it on and finally disgorge it in such a way or in such a position that it may be carried out of the oscula. The siliceous part of it may be used in forming spicules.

It is generally believed that the green corpuscles play an important part in the nutrition of those sponges in which they occur, and there can be no doubt that these bodies have the power peculiar to all organisms that produce chlorophyll of obtaining nutritive substances direct from water and carbonic oxide through the action of sunlight. Possibly they hand on some of the nourishment thus obtained to the sponges in which they live, or benefit them by the free oxygen given out in the process, but many Spongillidæ do well without them, even when living in identical conditions with species in which they abound.

Reproduction.

Both eggs and buds are produced by freshwater sponges (the latter rarely except by one species), while their gemmules attain an elaboration of structure not observed in any other family of sponges.

Probably all Spongillidæ are potentially monœcious, that is to say, able to produce both eggs and spermatozoa. In one Indian species, however, in which budding is unusually common (viz. *Spongilla proliferens*), sexual reproduction takes place very seldom, if ever. It is not known whether the eggs of sponges are fertilized by spermatozoa from the individual that produces the egg or by those of other individuals, but not improbably both methods of fertilization occur.

The egg of a freshwater sponge does not differ materially from that of other animals. When mature it is a relatively large spherical cell containing abundant food-material and situated in some natural cavity of the sponge. In the earlier stages of its growth, however, it exhibits amœboid movements, and makes its way through the common jelly. As it approaches maturity it is surrounded by other cells which contain granules of food-material. The food-material is apparently transferred by them

in a slightly altered form to the egg The egg has no shell, but in some species (e g *Ephydatia blembingia* *) it is surrounded, after fertilization, by gland-cells belonging to the parent sponge, which secrete round it a membrane of spongin Development goes on within the chamber thus formed until the larva is ready to assume a free life

The spermatozoon is also like that of other animals, consisting of a rounded head and a lash-like tail, the movements of which enable it to move rapidly through the water Spermatozoa are produced in *Spongilla* from spherical cells not unlike the eggs in general appearance The contents of these cells divide and subdivide in such a way that they finally consist of a mass of spermatozoa surrounded by a single covering cell, which they finally rupture, and so escape

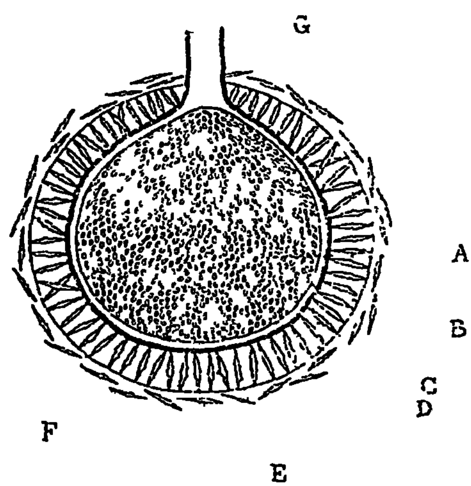

Fig 7 —Diagram of a vertical section through the gemmule of *Spongilla proliferens*

A=cellular contents B=internal chitinous layer, C=external chitinous layer, D=pneumatic coat, E=gemmule-spicule, F=external membrane, G=foraminal tubule

Gemmules are asexual reproductive bodies peculiar to the sponges, but not to the Spongillidæ They resemble the statoblasts of the phylactolæmatous polyzoa in general structure as well as in function, which is mainly that of preserving the race from destruction by such agencies as drought, starvation, and temperatures that are either too high or too low for its activities This function they are enabled to perform by the facts that they are provided with coverings not only very hard but also fitted to resist the unfavourable agencies to which the gemmules are likely

* Rec Ind Mus i, p 269 (1907)

to be exposed, and that they contain abundant food-material of which use can be made as soon as favourable conditions occur again

Internally the gemmule consists of a mass of cells containing food-material in what may be called a tabloid form, for it consists of minutely granular plate-like bodies These cells are enclosed in a flask-like receptacle, the walls of which consist of two chitinous layers, a delicate inner membrane and an outer one of considerable stoutness The mouth of the flask is closed by an extension of the inner membrane, and in some species is surrounded by a tubular extension of the external membrane known as the foraminal tubule Externally the gemmule is usually covered by what is called a "pneumatic coat," also of "chitin" (spongin), but usually of great relative thickness and honeycombed by spaces which contain air, rendering the structure buoyant. The pneumatic coat also contains the microscleres characteristic of the species; it is often limited externally by a third chitinous membrane, on which more gemmule-spicules sometimes lie parallel to the surface

The cells from which those of the gemmules are derived are akin in origin to those that give rise to eggs and spermatozoa Some zoologists are therefore of the opinion that the development of the gemmule is an instance of parthenogenesis—that is to say of an organism arising from an egg that has not been fertilized. But some of the collar-cells, although most of them originate from the external ciliated cells of the larva, have a similar origin The building-up of the gemmule affords an excellent instance of the active co-operation that exists between the cells of sponges, and of their mobility, for the food-material that has to be stored up is brought by cells from all parts of the sponge, and these cells retire after discharging their load into those of the young gemmule

The formation of the gemmule of *Ephydatia blembingia*, a Malayan species not yet found in India, is described in detail by Dr R Evans (Q J Microsc Sci. London, xliv, p 81, 1901)

Gemmules are produced by the freshwater sponges of Europe, N. America and Japan at the approach of winter, but in the tropical parts of India they are formed more frequently at the approach of the hot weather (p 4) After they are fully formed the sponge that has produced them dies, and as a rule disintegrates more or less completely In some species, however, the greater part of the skeleton remains intact, if it is not disturbed, and retains some of the gemmules in its meshwork, where they finally germinate Other gemmules are set free Some of them float on the surface of the water, others sink to the bottom In any case all of them undergo a period of quiescence before germinating It has been found that they can be kept dry for two years without dying

The function of the special spicules with which the gemmules

of the Spongillidæ are provided appears to be not only to protect them but more especially to weight them to the extent suitable to the habits of each species Species that inhabit running water, for example, in some cases have heavier gemmule-spicules than those that live in stagnant water, and their gemmules are the less easily carried away by the currents of the river The gemmules of sponges growing in lakes are sometimes deficient in spicules This is the case as regards the form of *Spongilla lacustris* found in Lake Baa, Isle of Mull, as regards *S helvetica* from the Lake of Geneva, *S moorei* from Lake Tanganyika, and *S coggini* from Tali-Fu in Yunnan, also as regards the species of *Spongilla* and *Ephydatia* found in Lake Baikal, many of the sponges of which are said never to produce gemmules

Except in the genus *Corvospongilla* and the subgenus *Stratospongilla*, in both of which the air-spaces of the gemmules are usually no more than cavities between different chitinous membranes, the pneumatic coat is either "granular" or "cellular" Neither of these terms, however, must be understood in a physiological sense, for what appear to be granules in a granular coat are actually minute bubbles of air contained in little cavities in a foam-like mass of chitin (or rather spongin), while the cells in a cellular one are only larger and more regular air-spaces with thin polygonal walls and flat horizontal partitions The walls of these spaces are said in some cases to contain a considerable amount of silica

The gemmules with their various coverings are usually spherical in shape, but in some species they are oval or depressed in outline They lie as a rule free in the substance of the sponge, but in some species adhere at its base to the object to which it is attached In some species they are joined together in groups, but in most they are quite free one from another

Reproductive buds * are produced, so far as is known, by very few Spongillidæ, although they are common enough in some other groups of sponges In the only freshwater species in which they have been found to form a habitual means of reproduction, namely in *Spongilla proliferens*, they have much the appearance of abortive branches, and it is possible that they have been overlooked for this reason in other species, for they were noticed by Laurent in *Spongilla lacustris* as long ago as 1840 (CR Sé Acad Sci Paris, xi, p 478) The buds noticed by Laurent, however, were only produced by very young sponges, and were of a different nature from those of *S proliferens*, perhaps representing a form of fission rather than true budding (see 'Voyage de la Bonite Zoophytologie,' Spongiaires, pl i (Paris, 1844))

In *Spongilla proliferens*, a common Indian species, the buds arise

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* Proliferation whereby more than one osculum is produced is really a form of budding, but in most sponges this has become no longer a mode of reproduction but the normal method by which size is increased, and must therefore be considered merely as a vegetative process

as thickenings of the strands of cells accompanying the radiating spicule-fibres of the skeleton, which project outwards from the surface of the sponge The thickenings originate beneath the surface and contain, at the earliest stage at which I have as yet examined them, all the elements of the adult organism (*i. e.* flesh-spicules, ciliated chambers, efferent and afferent canals, parenchyma-cells of various sorts) except skeleton fibres, gemmules, and a dermal membrane A section at this period closely resembles one of an adult sponge, except that the structure is more compact, the parenchyma being relatively bulky and the canals of small diameter.

Laurent observed reproduction by splitting in young individuals of *Spongilla*, but I have not been able to obtain evidence myself that this method of reproduction occurs normally in Indian species In injured specimens of *Spongilla carteri*, however, I have observed a phenomenon that seems to be rather an abnormal form of budding, little rounded masses of cells making their way to the ends of the radiating skeleton fibres and becoming transformed into young sponges, which break loose and so start an independent existence Possibly the buds observed by Laurent in *S lacustris* were of a similar nature.

Development.

(a) *From the Egg.*

After fertilization, the egg, lying in its cavity in the sponge, undergoes a complete segmentation, that is to say, becomes divided into a number of cells without any residuum remaining The segmentation, however, is not equal, for it results in the formation of cells of two distinct types, one larger and less numerous than the other As the process continues a pear-shaped body is produced, solid at the broader end, which consists of the larger cells, but hollow at the other. Further changes result in the whole of the external surface becoming ciliated or covered with fine protoplasmic lashes, each of which arises from a single small cell, considerable differentiation now takes place among the cells, and spicules begin to appear At this stage or earlier (for there seem to be differences in different species and individuals as to the stage at which the young sponge escapes) the larva makes its way out of the parent sponge. After a brief period of free life, in which it swims rapidly through the water by means of its cilia, it fixes itself by the broad end to some solid object (from which it can never move again) and undergoes a final metamorphosis During this process the ciliated cells of the external layer make their way, either by a folding-in of the whole layer or in groups of cells, into the interior, there change into collar-cells and arrange themselves in special cavities—the ciliated chambers of the adult Finally an osculum, pores, &c, are formed, and the sponge is complete.

This, of course, is the merest outline of what occurs, other changes that take place during the metamorphosis are of great theoretical interest, but cannot be discussed here The student may refer to Dr R Evans's account of the larval development of *Spongilla lacustris* in the Q. J Microsc Sci London, xlii, p 363 (1899)

(b) *From the Gemmule*

The period for which the gemmule lies dormant probably depends to some extent upon environment and to some extent on the species to which it belongs Carter found that if he cleaned gemmules with a handkerchief and placed them in water exposed to sunlight, they germinated in a few days, but in Calcutta gemmules of *Spongilla alba* var *bengalensis* treated in this way and placed in my aquarium at the beginning of the hot weather, did not germinate until well on in the "rains" Even then, after about five months, only a few of them did so Zykoff found that in Europe gemmules kept for two years were still alive and able to germinate

Germination consists in the cellular contents of the gemmule bursting the membrane or membranes in which they are enclosed, and making their way out of the gemmule in the form of a delicate whitish mass, which sometimes issues through the natural aperture in the outer chitinous coat and sometimes through an actual rent in this coat In the latter case the development of the young sponge is more advanced than in the former

The fullest account of development from the gemmule as yet published is by Zykoff, and refers to *Ephydatia* in Europe (Biol Centralbl Berlin, xii, p 713, 1892)

His investigations show that the bursting of the gemmule is not merely a mechanical effect of moisture or any such agency but is due to development of the cellular contents, which at the time they escape have at least undergone differentiation into two layers Of the more important soft structures in the sponge the osculum is the first to appear, the ciliated chambers being formed later This is the opposite of what occurs in the case of the bud, but in both cases the aperture appears to be produced by the pressure of water in the organism The manner and order in which the different kinds of cells originate in the sponge derived from a gemmule give support to the view that the primitive cell-layers on which morphologists lay great stress are not of any great importance so far as sponges are concerned

(c) *Development of the Bud*

As the bud of *Spongilla proliferens* grows it makes its way up the skeleton-fibre to which it was originally attached, pushing the dermal membrane, which expands with its growth, before it. The

skeleton-fibre does not, however, continue to grow in the bud, in which a number of finer fibres make their appearance, radiating from a point approximately at the centre of the mass As the bud projects more and more from the surface of the sponge the dermal membrane contracts at its base, so as finally to separate it from its parent Further details are given on p 74

HABITAT.

Mr Edward Potts*, writing on the freshwater sponges of North America, says —"These organisms have occasionally been discovered growing in water unfit for domestic uses, but as a rule they prefer pure water, and in my experience the finest specimens have always been found where they are subjected to the most rapid currents" True as this is of the Spongillidæ of temperate climates, it is hardly applicable to those of tropical India, for in this country we find many species growing most luxuriantly and commonly in water that would certainly be considered unfit for domestic purposes in a country in which sanitation was treated as a science Some species, indeed, are only found in ponds of water polluted by human agency, and such ponds, provided that other conditions are favourable, are perhaps the best collecting grounds Other favourable conditions consist in a due mixture of light and shade, a lack of disturbance such as that caused by cleaning out the pond, and above all in the presence of objects suitable for the support of sponges

I do not know exactly why light and shade must be mixed in a habitat favourable for the growth of sponges, for most species prefer shade, if it be not too dense, but it is certainly the case that, with a few exceptions, Indian Spongillidæ flourish best in water shaded at the edges by trees and exposed to sunlight elsewhere One of the exceptions to this rule is the Indian race of *Spongilla lacustris*, which is found in small pools of water in sand-dunes without a particle of shade Several species are only found on the lower surface of stones and roots in circumstances which do not suggest that their position merely protects them from mud, which, as Mr Potts points out, is their "great enemy." A notable instance is *Trochospongilla pennsylvanica*, which is found hiding away from light in America and Europe as well as in India

It is curious that it should be easy to exterminate the sponges in a pond by cleaning it out, for one would have thought that sufficient gemmules would have remained at the edge, or would have been brought rapidly from elsewhere, to restock the water. Mr Green has, however, noted that *Spongilla carteri* has disappeared for some years from a small lake at Peradeniya in which it was formerly abundant, owing to the lake having been cleaned

* P Ac Philad 1887, p 162

out, and I have made similar observations on several occasions in Calcutta.

The question of the objects to which sponges attach themselves is one intimately connected with that of the injury done them by mud. The delta of the Ganges is one of the muddiest districts on earth. There are no stones or rocks in the rivers and ponds, but mud everywhere. If a sponge settles in the mud its canals are rapidly choked, its vital processes cease, and it dies. In this part of India, therefore, most sponges are found fixed either to floating objects such as logs of wood, to vertical objects such as the stems of bulrushes and other aquatic plants, or to the tips of branches that overhang the water and become submerged during the "rains." In Calcutta man has unwittingly come to the assistance of the sponges not only by digging tanks but also by building "bathing-ghats" of brick at the edge, and constructing, with æsthetic intentions if not results masses of artificial concrete rocks in or surrounding the water. There are at least two sponges (the typical form of *Spongilla alba* and *Ephydatia meyeni*) which in Calcutta are only found attached to such objects. The form of *S. alba*, however, that is found in ponds of brackish water in the Gangetic delta has not derived this artificial assistance from man, except in the few places where brick bridges have been built, and attaches itself to the stem and roots of a kind of grass that grows at the edge of brackish water. This sponge seems to have become immune even to mud, the particles of which are swallowed by its cells and finally got rid of without blocking up the canals.

Several Indian sponges are only found adhering to stones and rocks. Among these species *Corvospongilla lapidosa* and our representatives of the subgenus *Stratospongilla* are noteworthy. Some forms (e. g. *Spongilla carteri* and *S. crateriformis*) seem, however, to be just as much at home in muddy as in rocky localities, although they avoid the mud itself.

There is much indirect evidence that the larvæ of freshwater sponges exercise a power of selection as regards the objects to which they affix themselves on settling down for life.

Few Spongillidæ are found in salt or brackish water, but *Spongilla alba* var. *bengalensis* has been found in both, and is abundant in the latter; indeed, it has not been found in pure fresh water. *Spongilla travancorica* has only been found in slightly brackish water, while *S. lacustris* subsp. *reticulata* and *Dosilia plumosa* occur in both fresh and brackish water, although rarely in the latter. The Spongillidæ are essentially a freshwater family, and those forms that are found in any but pure fresh water must be regarded as aberrant or unusually tolerant in their habits, not as primitive marine forms that still linger halfway to the sea.

ANIMALS AND PLANTS COMMONLY ASSOCIATED WITH FRESHWATER SPONGES

(a) *Enemies*

Freshwater sponges have few living enemies Indeed, it is difficult to say exactly what is an enemy of a creature so loosely organized as a sponge There can be little doubt, in any case, that the neuropteroid larva (*Sisyra indica*) which sucks the cells of several species should be classed in this category, and it is noteworthy that several species of the same genus also occur in Europe and N America which also attack sponges Other animals that may be enemies are a midge larva (*Tanypus* sp) and certain worms that bore through the parenchyma (p 93), but I know of no animal that devours sponges bodily, so long as they are uninjured If their external membrane is destroyed, they are immediately attacked by various little fish and also by snails of the genera *Limnæa* and *Planorbis*, and prawns of the genus *Palæmon*

Their most active and obvious enemy is a plant, not an animal, —to wit, a filamentous alga that blocks up their canals by its rapid growth (p 79)

(b) *Beneficial Organisms.*

The most abundant and possibly the most important organisms that may be considered as benefactors to the Spongillidæ are the green corpuscles that live in the cells of certain species (fig 2, p 31), notably *Spongilla lacustris*, *S proliferens*, and *Dosilia plumosa* I have already said that these bodies are in all probability algæ which live free in the water and move actively at one stage of their existence, but some of them are handed on directly from a sponge to its descendants in the cells of the gemmule In their quiescent stage they have been studied by several zoologists, notably by Sir Ray Lankester * and Dr W Weltner †, but the strongest light that has been cast on their origin is given by the researches of Dr F W Gamble and Mr F Keeble (Q J Microsc Sci London, xlvii, p 363, 1904, and li, p 167, 1907) These researches do not refer directly to the Spongillidæ but to a little flat-worm that lives in the sea, *Convoluta roscoffensis* The green corpuscles of this worm so closely resemble those of *Spongilla* that we are justified in supposing a similarity of origin It has been shown by the authors cited that the green corpuscles of the worm are at one stage minute free-living organisms provided at one end with four flagella and at the other with a red pigment spot The investigators are of the opinion that these organisms exhibit

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* Q J Microsc Sci London, xxii, p 229 (1882)
† Arch Naturg Berlin, lix (i), p 260 (1893)

the essential characters of the algæ known as Chlamydomonadæ, and that after they have entered the worm they play for it the part of an excretory system

As they exist in the cells of *Spongilla* the corpuscles are minute oval bodies of a bright green colour and each containing a highly refractile colourless granule A considerable number may be present in a single cell It is found in European sponges that they lose their green colour if the sponge is not exposed to bright sunlight In India, however, where the light is stronger, this is not always the case Even when the colour goes, the corpuscles can still be distinguished as pale images of their green embodiment They are called *Chlorella* by botanists, who have studied their life-history but have not yet discovered the full cycle See Beyerinck in the Botan Zeitung for 1890 (vol xlviii, p 730, pl vii, Leipzig), and for further references West's 'British Freshwater Algæ,' p 230 (1904).

The list of beneficent organisms less commonly present than the green corpuscles includes a *Chironomus* larva that builds parchment-like tubes in the substance of *Spongilla carteri* and so assists in supporting the sponge, and of a peculiar little worm (*Chætogaster spongillæ* *) that appears to assist in cleaning up the skeleton of the same sponge at the approach of the hot weather and in setting free the gemmules (p 93)

(c) *Organisms that take shelter in the Sponge or adhere to it externally*

There are many animals which take shelter in the cavities of the sponge without apparently assisting it in any way Among these are the little fish *Gobius alcockii*, which lays its eggs inside the oscula of *S carteri*, thus ensuring not only protection but also a proper supply of oxygen for them (p 94), the molluscs (*Corbula* spp) found inside *S alba* var *bengalensis* (p 78), and the Isopod (*Tachæa spongillicola*) that makes its way into the oscula of *Spongilla carteri* and *S crateriformis* (pp 86, 94)

In Europe a peculiar ciliated Protozoon (*Trichodina spongillæ*) is found attached to the external surface of freshwater sponges I have noticed a similar species at Igatpuri on *Spongilla crateriformis*, but it has not yet been identified It probably has no effect, good or bad, on the sponge

Freshwater Sponges in relation to Man

In dealing with *Spongilla carteri* I have suggested that sponges may be of some hygienic importance in absorbing putrid organic matter from water used both for ablutionary and for drinking purposes, as is so commonly the case with regard to ponds in India Their bad odour has caused some species of Spongillidæ

* Journ As Soc Beng n s ii, 1906, p 189

to be regarded as capable of polluting water, but a mere bad odour does not necessarily imply that they are insanitary

Unless my suggestion that sponges purify water used for drinking purposes by absorbing putrid matter should prove to be supported by fact, the Spongillidæ cannot be said to be of any practical benefit to man The only harm that has been imputed to them is that of polluting water*, of blocking up water-pipes by their growth—a very rare occurrence,—and of causing irritation to the human skin by means of their spicules—a still rarer one At least one instance is, however, reported in which men digging in a place where a pond had once been were attacked by a troublesome rash probably due to the presence of sponge-spicules in the earth, and students of the freshwater sponges should be careful not to rub their eyes after handling dried specimens

Indian Spongillidæ compared with those of other Countries.

In Weltner's catalogue of the freshwater sponges (1895) seventy-six recent species of Spongillidæ (excluding *Lubomirskia*) are enumerated, and the number now known is well over a hundred In India we have twenty-nine species, subspecies, and varieties, while from the whole of Europe only about a dozen are known In the neighbourhood of Calcutta nine species, representing three genera and a subgenus, have been found, all of them occur in the Museum tank The only other region of similar extent that can compare with India as regards the richness of its freshwater sponge fauna is that of the Amazon, from which about twenty species are known From the whole of North America, which has probably been better explored than any other continent so far as Spongillidæ are concerned, only twenty-seven or twenty-eight species have been recorded

The Indian species fall into seven genera, one of which (*Spongilla*) consists of three subgenera With one exception (that of *Pectispongilla*, which has only been found in Southern India) these genera have a wide distribution over the earth's surface, and this is also the case as regards the subgenera of *Spongilla*. Four genera (*Heteromeyenia*, *Acalle*, *Parmula*, and *Uruguaya*) that have not yet been found in India are known to exist elsewhere

Five of the Indian species are known to occur in Europe, viz , *Spongilla lacustris*, *S crateriformis*, *S carteri*, *S fragilis*, *Trochospongilla pennsylvanica*, while *Ephydatia meyeni* is intermediate between the two commonest representatives of its genus in the Holarctic Zone, *Ephydatia fluviatilis* and *E mulleri* Of the species that occur both in India and in Europe, two (*Spongilla*

* See Potts, Proc Ac Philad 1884, p 23

lacustris and *S fragilis*) are found in this country in forms sufficiently distinct to be regarded as subspecies or local races Perhaps this course should also be taken as regards the Indian forms of *S carteri*, of which, however, the commonest of the Indian races would be the typical one, but *S crateriformis* and *T pennsylvanica* seem to preserve their specific characters free from modification, whether they are found in Europe, Asia, or America

The freshwater sponges of Africa have been comparatively little studied, but two Indian species have been discovered, *S bombayensis* in Natal and *S alba* var *cerebellata* in Egypt Several of the species from the Malabar Zone are, moreover, closely allied to African forms (p 11)

Fossil Spongillidæ.

The Spongillidæ are an ancient family Young described a species (*Spongilla purbeckensis*) from the Upper Jurassic of Dorset (Geol Mag London (new series) v, p 220 (1878)), while spicules, assigned by Ehrenberg to various genera but actually those of *Spongilla lacustris* or allied forms, have been found in the Miocene of Bohemia (see Ehrenberg's 'Atlas fur Micro-Geologie,' pl xi (Leipzig, 1854), and Traxler in Foldt Kozl, Budapest, 1895, p 211) *Ephydatia* is also known in a fossil condition, but is probably less ancient than *Spongilla*

Ehrenberg found many sponge spicules in earth from various parts of the Indian Empire (including Baluchistan, Mangalore, Calcutta, the Nicobars and Nepal) and elsewhere, and it might be possible to guess at the identity of some of the more conspicuous species figured in his 'Atlas' The identification of sponges from isolated spicules is, however, always a matter of doubt, and in some cases Ehrenberg probably assigned spicules belonging to entirely different families or even orders to the same genus, while he frequently attributed the different spicules of the same species to different genera. Among his fossil (or supposed fossil) genera that may be assigned to the Spongillidæ wholly or in part are *Aphidiscus*, *Spongolithis*, *Lithasteriscus* and *Lithosphæridium*, many of the species of these "genera" certainly belonging to *Spongilla* and *Ephydatia*

Oriental Spongillidæ not yet found in India

Few freshwater sponges that have not been found in India are as yet known from the Oriental Region, and there is positive as well as negative evidence that Spongillidæ are less abundant in Malaysia than in this country The following list includes the names of those that have been found, with notes regarding each species It is quite possible that any one of them may be found at any time within the geographical boundaries laid down for this 'Fauna' I have examined types or co-types in all cases except that of *Ephydatia fortis*, Weltner

I *Spongilla (Euspongilla) microsclerifera* *, Annandale (Philippines). P U.S. Mus xxxvii, p 131 (1909)

This sponge is closely related to *S lacustris*, but apparently does not produce branches It is remarkable for the enormous number of microscleres in its parenchyma

II *S (Euspongilla) philippinensis* *, Annandale (Philippines) P U S Mus xxxvi, p 629 (1909)

Related to *S alba* and still more closely to *S sceptrioides* of Australia From the former it is readily distinguished by having minutely spined megascleres, green corpuscles, slender gemmule-spicules with short spines and no free microscleres

III *S (? Euspongilla) yunnanensis* *, Annandale (W China) Rec Ind Mus v, p 197 (1910)

Apparently allied to *S philippinensis* but with smooth skeleton-spicules and a more delicate skeleton.

IV *S (Stratospongilla) sinensis* *, Annandale (Foochow, China) P U S Mus xxxviii, p 183 (1910)

This species and *S clementis* are referred to *Stratospongilla* with some doubt Their gemmules are intermediate in structure between those of that subgenus and those of *Euspongilla* In *S sinensis* the gemmules are packed together in groups at the base of the sponge, and their spicules are smooth, stout, and gradually pointed

V *S (Stratospongilla) clementis* *, Annandale (Philippines) P U S Mus xxxvi, p 631 (1909)

The gemmules are single and closely adherent at the base of the sponge Their spicules are very slender and minutely spined

VI *S. (? Stratospongilla) coggini* *, Annandale (W. China) Rec. Ind Mus. v, p 198 (1910)

The gemmules apparently lack microscleres They resemble those of *S. clementis*, to which the species is probably related, in other respects The skeleton-spicules are spiny and rather stout, the species being strongly developed at the two ends

VII *S (Stratospongilla) sumatrana* *, Weber (Malay Archipelago) Zool Ergebnisse einer Reise in Niederlandisch Ost-Indien, i, p 38 (1890)

Closely allied to *S indica* (p 100) but with pointed skeleton-spicules

VIII *Ephydatia fortis*, Weltner (Philippines) Arch. Naturgesch lxi (i), p 141 (1895).

This species is remarkable for the great development of the spines on the shaft of the gemmule-spicules.

IX *Ephydatia bogorensis* *, Weber (Malay Archipelago) Zool Ergebnisse einer Reise in Niederlandisch Ost-Indien, i, p. 33 (1890)

The gemmule-spicules have rather narrow flattish disks, the edge of which is feebly but closely serrated

X *E. blembingia* *, Evans (Malay Peninsula) Q J. Microsc Sci London, xliv, p 81 (1901)

The gemmules resemble those of *Dosilia plumosa* but are spherical There are no free microscleres

XI *Tubella vesparium* *, v. Martens (Borneo) Arch. Naturg Berlin, xxxiv, p 62 (1868)

Closely related to *T vesparioides* (p 189), but with spiny megascleres

As regards *Spongilla decipiens* *. Weber, from the Malay Archipelago, see p 97.

II.

History of the Study of Freshwater Sponges

The bath-sponge was known to the Greeks at an early date, and Homer refers to it as being used for cleansing furniture, for expunging writing, and for ablutionary purposes He also mentions its peculiar structure, "with many holes" "Many things besides," wrote the English naturalist Ray in his 'Historia Plantarum' (1686), "regarding the powers and uses of sponges have the Ancients. to them refer." Ray himself describes at least one freshwater species, which had been found in an English river, and refers to what may be another as having been brought from America In the eighteenth century Linne, Pallas and other authors described the commoner European Spongillidæ in general terms. sometimes as plants and sometimes as animals, more usually as zoophytes or "plant-animals" partaking of the nature of both kingdoms. The gemmules were noted and referred to as seeds. The early naturalists of the Linnæan Epoch, however, added little to the general knowledge of the Spongillidæ, being occupied with theory in which theological disputes were involved rather than actual observation, and, notwithstanding the fact that the animal nature of sponges was clearly demonstrated by Ellis † in 1765, it was not until the nineteenth century was well advanced that zoologists could regard sponges in anything like an impartial manner.

One of the pioneers in the scientific study of the freshwater

† Phil Trans Roy Soc. lv, p 280

forms was the late Dr H J Carter, who commenced his investigations, and carried out a great part of them, in Bombay with little of the apparatus now considered necessary, and with a microscope that must have been grossly defective according to modern ideas His long series of papers (1848–1887) published in the 'Annals and Magazine of Natural History' is an enduring monument to Indian zoology, and forms the best possible introduction to the study of the Spongillidæ Even his earlier mistakes are instructive, for they are due not so much to actual errors in observation as to a faithful transcription of what was observed with faulty apparatus

Contemporary with Carter were two authors whose monographs on the freshwater sponges did much to advance the study of the group, namely, J S Bowerbank, whose account of the species known at the time was published in the 'Proceedings of the Zoological Society of London' in 1882, and the veteran American naturalist Mr. Edward Potts, whose study of the freshwater sponges culminated in his monograph published in the 'Proceedings of the Academy of Natural Sciences of Philadelphia' in 1887 Carter's own revision of the group was published in the 'Annals and Magazine of Natural History' in 1881. The names of Vejdovsky, who prefaced Potts's monograph with an account of the European species, and of Dybowsky, who published several important papers on classification, should also be mentioned, while Weltner's catalogue of the known species (1895) is of the greatest possible value to students of the group

Many authors have dealt with the physiology, reproduction and development of the Spongillidæ, especially in recent years, Dr R Evans's description of the larva of *Spongilla lacustris* (1899), and his account of the development of the gemmule in *Ephydatia blembingia* (1901), Zykoff's account of the development of the gemmule and of the sponge from the gemmule (1892), and Weltner's observations on colour and other points (1893, 1907), may be mentioned in particular. Laurent's observations on development (1844), which were published in the 'Voyage de la Bonite,' and especially the exquisite plates which accompany them, have not received the notice they deserve, probably on account of their method of publication

LITERATURE.

The fullest account of the literature on the Spongillidæ as yet published will be found in the first of Weltner's 'Spongillidenstudien' (Archiv fur Naturgeschichte, lix (1), p 209, 1893) Unfortunately it contains no references of later date than 1892 The following list is not a complete bibliography, but merely a list of books and papers that should prove of use to students of the Oriental Spongillidæ.

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GLOSSARY OF TECHNICAL TERMS USED IN PART I.

Amphioxi (adj *amphioxous*)	Rod-like spicules sharp at both ends
Amphistrongyli (adj *amphistrongylous*)	Rod-like spicules blunt at both ends
Basal membrane	A horny, structureless membrane found at the base of some sponges
Birotulate (subst or adj)	Spicule with a transverse disk at both ends
Bubble-cells .	Spherical cells of the parenchyma the contents of which consist of a drop of liquid covered by a thin film of protoplasm
Ciliated (or *flagellated*) *chamber*	A cavity lined with collar-cells
Collar-cell (*choanocyte*) .	Cell provided at one end with a membranous collar and a vibratile lash or flagellum that springs from within the collar.
Derma or *ectodermal layer*	A layer of flat cells arranged like a pavement on the surface of the sponge
Exhalent (or *efferent*) *canal*	A tubular canal through which water passes from a ciliated chamber towards the osculum
Fibres (skeleton)	Thread-like structures that compose the skeleton of the sponge and are formed (in the Spongillidæ) mainly of overlapping spicules
Flesh-spicules .	Microscleres (*q v*) that lie free in the parenchyma and the derma
Foramen	An orifice of the gemmule
Foraminal tubule .	A horny tube that surrounds the foramina of some gemmules
Gemmule .	A mass of cells packed with food-material, surrounded by at least one horny coat, capable of retaining vitality in unfavourable conditions and finally of giving origin to a new sponge
Green corpuscles . .	Minute green bodies found inside cells of sponges and other animals and representing a stage in the life-history of an alga (*Chlorella*)

Inhalent (or *afferent*) *canal* — A tubular canal through which water passes from the exterior towards a ciliated chamber

Megascleres — The larger spicules that (in the Spongillidæ) form the basis of the skeleton of the sponge

Microscleres — Smaller spicules that lie free in the substance or the derma of the sponge, or are associated with the gemmule

Monaxon — (Of spicules) having a single main axis, (of sponges) possessing skeleton spicules of this type

Osculum — An aperture through which water is ejected from the sponge

Oscular collar — A ring-shaped membrane formed by an extension of the derma round an osculum

Parenchyma — The gelatinous part of the sponge

Pavement layer — Adherent gemmules arranged close together in a single layer at the base of a sponge

Pneumatic coat — A horny or chitinous layer on the surface of the gemmule containing air-spaces If these spaces are of regular form and arrangement it is said to be *cellular*, if they are minute and irregular it is called *granular*

Pore — A minute hole through which water is taken into the sponge

Pore-cell (*porocyte*) — A cell pierced by a pore

Radiating fibres — Fibres in the skeleton of a sponge that are vertical or radiate from its centre

Rotula — A transverse disk borne by a microsclere

Rotulate (subst or adj) — Spicule bearing one or two transverse disks

Spicule — A minute mineral body of regular and definite shape due not to the forces of crystallization but to the activity of the living cell or cells in which it is formed

Spongin — The horny substance found in the skeletal framework and the coverings of gemmules of sponges Structures formed of this substance are often referred to as *chitinous*

Subdermal cavity — A cavity immediately below the derma (*q v*)

Transverse fibres — Fibres in the skeleton of a sponge that run across between the radiating fibres

Tubelliform (of spicule) — Having a straight shaft with a transverse disk at one end and a comparatively small knob-like projection at the other

SYSTEMATIC LIST OF THE INDIAN SPONGILLIDÆ.

[Types, schizotypes, or cotypes have been examined in the case of all species, &c., whose names are marked thus, *.]

Genus 1. SPONGILLA, Lamarck (1816).

Subgenus A. EUSPONGILLA, Vejdovsky (1883).

1. ? *S. lacustris*, auct. (perhaps in N.W. India).
1 *a*. *S. lacustris* subsp. *reticulata* *, Annandale (1907).
2. *S. proliferens* *, Annandale (1907).
3. *S. alba* *, Carter (1849).
3 *a*. *S. alba* var. *cerebellata*, Bowerbank (1863).
3 *b*. *S. alba* var. *bengalensis* *, Annandale (1906).
4. *S. cinerea* *, Carter (1849).
5. *S. travancorica* *, Annandale (1909).
6. *S. hemephydatia* *, Annandale (1909).
7. *S. crateriformis* * (Potts) (1882).

Subgenus B. EUNAPIUS, J. E. Gray (1867).

8. *S. carteri* *, Carter (1849).
8 *a*. *S. carteri* var. *mollis* *, nov.
8 *b*. *S. carteri* var. *cava* *, nov.
8 *c*. *S. carteri* var. *lobosa* *, nov.
9 *a*. *S. fragilis* subsp. *calcuttana* *, nov.
9 *b*. *S. fragilis* var. *decipiens*, Weber (probably Malaysian, not Indian).
10. *S. gemina* *, sp. nov.
11. *S. crassissima* *, Annandale (1907).
11 *a*. *S. crassissima* var. *crassior* *, Annandale (1907).

Subgenus C. STRATOSPONGILLA, Annandale (1909).

12. *S. indica* *, Annandale (1908).
13. *S. bombayensis* *, Carter (1882).
14. *S. ultima* *, Annandale (1910).

Genus 2. PECTISPONGILLA, Annandale (1909).

15. *P. aurea* *, Annandale (1909).
15 *a*. *P. aurea* var. *subspinosa* *, nov.

Genus 3 EPHYDATIA, Lamouroux (1816)

16 *E. meyeni* * (Carter) (1849)

Genus 4 DOSILIA, J. E. Gray (1867)

17 *D. plumosa* * (Carter) (1849)

Genus 5 TROCHOSPONGILLA, Vejdovsky (1883).

18 *T. latoucheana* *, Annandale (1907)
19 *T. phillottiana* *, Annandale (1907)
20 *T. pennsylvanica* * (Potts) (1882)

Genus 6 TUBELLA, Carter (1881)

21 *T. vesparioides* *, Annandale (1908)

Genus 7 CORVOSPONGILLA, nov.

22 *C. burmanica* * (Kirkpatrick) (1908).
23 *C. lapidosa* * (Annandale) (1908)

Order HALICHONDRINA.

Siliceous monaxon sponges in which the horny skeleton is much reduced or absent and the spicular skeleton is more or less definitely reticulate The microscleres are usually rod-like and rarely have more than one main axis

Family SPONGILLIDÆ

SPONGILLADÆ, J E Gray, P Zool Soc London, 1867, p 550

Freshwater Halichondrina which at certain seasons produce gemmules armed with peculiar microscleres Two distinct kinds of microsclere are often present, that associated with the gemmule sometimes consisting of a vertical shaft at the ends of which transverse disks or rotulæ are borne. There is always at least a trace of a subdermal cavity.

Many authors divide the Spongillidæ into two subfamilies — Spongillinæ (or Euspongillinæ), in which the gemmule-spicules have no transverse rotulæ, and Meyeninæ (or Ephydatiinæ), in which they have rotules at one or both ends So gradual, however, is the transition that I find it difficult to decide in one instance to which of two genera, typical respectively of the two "subfamilies," a species should be assigned Minchin in his account of the Porifera in Lankester's "Treatise on Zoology" (1900) regards the Spongillidæ merely as a subfamily of the Heterorrhaphidæ, and there certainly are few differences of a definite nature between them and the marine family (or subfamily) Renieridæ.

Key to the Indian Genera of Spongillidæ

I Microscleres without transverse disks
  A Microscleres of the parenchyma similar in general structure to those of the gemmule, the latter without comb-like vertical rows of spines at the ends — SPONGILLA, p 67
  B Microscleres of the gemmule with comb-like vertical rows of spines at both ends — TECTISPONGILLA, [p 106
F

II Some or all of the microscleres birotulate (Birotulate microscleres of one kind only)

A. Microscleres of the gemmule birotulate, the rotules with serrated or strongly sinuous edges, parenchyma spicules usually absent, never of complicated structure ... EPHYDATIA, p 108

B. Microscleres of the gemmule as in *Ephydatia*, microscleres of the parenchyma consisting of numerous shafts meeting in different planes in a central nodule . ... DOSILIA, p 110

C Microscleres as in *Ephydatia* except that the rotulæ of the gemmule-spicules have smooth edges ... TROCHOSPONGILLA, [p 113

D Microscleres of the gemmule without a trace of rotules, those of the parenchyma birotulate ... CORVOSPONGILLA, [nov, p 122

III Microscleres of the gemmule with a well-developed basal rotule and a vertical shaft ending above in a mere knob ... TUBELLA, p 120

The most distinct genus of Spongillidæ not yet found in India is *Heteromeyenia*, Potts It is easily distinguished from all others by the fact that the birotulate spicules of the gemmule are of two quite distinct kinds, which occur together on every mature gemmule *Heteromeyenia* is represented by several American species, one of which has been found in Europe *Acalle*, J E Gray, which is represented by a single South American species (*Spongilla recurvata*, Bowerbank), is related to *Heteromeyenia* but has one kind of gemmule-spicule tubelliform, the other birotulate Probably *Uruguaya*, Carter, should be regarded as a subgenus of *Trochospongilla* with an unusually solid skeleton, it is peculiar to S America *Parmula*, Carter (=*Drulia*, Gray) includes South American forms allied to *Tubella*, but with the shaft of the gemmule-spicule degenerate and consisting of a mere projection in the centre of a shield-like body, which represents the lower rotule The status of *Potamolepis*, Marshall, originally described from the Lake of Galilee, is very doubtful, possibly some or all of its species belong to the subgenus of *Spongilla* here called *Stratospongilla* (p 100), but they are stated never to produce gemmules The same is the case as regards *Pachydictyum*, Weltner, which consists of a single species from Celebes

The sponges from Lake Baikal assigned by Weltner (Arch Naturg lxi (1) p 131) to the subfamily Lubomirskinæ are of doubtful position and need not be considered here, while *Lessepsia*, Keller, from one of the salt lakes on the Suez Canal, certainly does not belong to the family, although it is assigned to it by von Lendenfeld (Mon Horny Sponges, p 904 (1889)) and subsequently by Minchin (Porifera, p 152, in Lankester's Treatise on Zoology, part ii (1900))

Genus 1 SPONGILLA, *Lamarck* (Carter *emend*)

Spongilla, Lamarck, Histoire des Animaux sans Vertebres, ii, p 111 (1836)
Spongilla, Carter, Ann Nat Hist (5) vii, p 86 (1881)
Euspongilla, Vejdovsky, Abh Bohm Ges xii, p 15 (1883)
Spongilla, Potts, P. Ac Philad 1887, p 182

TYPE, *Spongilla lacustris*, auctorum

Spongillidæ in which the gemmules have (normally) cylindrical or subcylindrical spicules that are sharp or blunt at the ends, without a distinct transverse disk or disks and without comb-like vertical rows of spines

The skeleton is variable in structure, sometimes being almost amorphous, sometimes having well-defined radiating and transverse fibres firmly compacted with spongin The skeleton-spicules are either sharp or blunt at the ends Flesh-spicules are often absent, when present they are needle-like and resemble the gemmule-spicules in general structure, they have not even rudimentary rotules at their ends The gemmules either lie free in the substance of the sponge or are attached to its support, sometimes they adhere together in free or attached groups

Spongilla is undoubtedly the most primitive genus of the Spongillidæ, its spicules showing less sign of specialization than those of any other genus included in the family As a fossil it goes back at any rate to the Upper Jurassic (p 52)

GEOGRAPHICAL DISTRIBUTION. — Cosmopolitan In most countries the majority of the freshwater sponges belong to this genus, but in Japan *Ephydatia* seems to predominate

Key to the Indian Species of Spongilla

I Gemmule provided with a thick, apparently granular pneumatic coat in which the gemmule-spicules are arranged tangentially or vertically (Subgenus *Euspongilla*, p 69)
- A No foraminal tubule
  - *a* Sponge bright green, soft and compressible when fresh, very fragile dry . . . *lacustris*, p. 69.
  - *a'* Sponge white or grey, hard both fresh and dry . . . *alba*, p 76
- B A foraminal tubule present
  - *b* Skeleton-spicules smooth
    - *β* Gemmules free, gemmule-spicules arranged tangentially and horizontally . . . *proliferens*, p 72.

β′ Gemmules free, gemmule-spicules arranged vertically or nearly so in a single series . *hemephydatia*, p 82

β″ Gemmules firmly fixed to the support of the sponge, gemmule-spicules almost vertical, irregularly arranged, as a rule in more than one series *travancorica*, p 81

b′. Skeleton-spicules spiny or irregular in outline

β‴ Gemmule spicules tangential and horizontal, without rudimentary rotules *cinerea*, p 79

β⁗ Gemmule-spicules vertical or nearly so, often with rudimentary rotules at the tips *crateriformis*, p 83.

II Gemmules surrounded in several layers by distinct polygonal air-spaces with chitinous walls (Subgenus *Eunapius*, p. 86)

A Gemmules single Skeleton- and gemmule-spicules smooth, pointed, not very stout *carteri*, p 87

B Gemmules bound together in pairs Skeleton friable, skeleton-spicules slender *gemina*, nov, p 97.

C Gemmules bound together in free groups of more than two or forming a "pavement-layer" at the base of the sponge

c Skeleton friable, skeleton-spicules slender *fragilis*, p 95

c′ Skeleton very hard and resistant, skeleton-spicules stout *crassissima*, p 98

III Gemmules without or with irregular pneumatic coat, covered by a chitinous membrane or membranes in which the gemmule-spicules lie parallel to the surface (Subgenus *Stratospongilla*, p 100)

A Skeleton spicules spiny or irregular in outline

a Skeleton-spicules blunt, gemmules covered by a single chitinous membrane *indica*, p 100

a′ Skeleton-spicules sharp, gemmules covered by two chitinous membranes *bombayensis*, p 102

B Skeleton-spicules smooth

Skeleton-spicules sharp, gemmule spicules very irregular in form *ultima*, p 104

Subgenus A EUSPONGILLA, *Vejdovsky*

Euspongilla, Vejdovsky, Abh Bohm Ges xii, p 15 (1883)
Euspongilla, *id*, in Potts's "Fresh-Water Sponges," P Ac Philad 1887, p 172
Euspongilla, Weltner, in Zacharias's Tier- und Pflanzenwelt des Susswassers, i, p 210 (1891)

TYPE, *Spongilla lacustris*, auctorum

Spongillæ in which the gemmules are covered with a thick, apparently granular pneumatic coat A delicate membrane often occurs outside this coat, but it is never thick or horny The gemmules usually lie free in the sponge but sometimes adhere to its support, rarely they are fastened together in groups (*e g* in *S aspinosa*, Potts) The skeleton-spicules are never very stout and the skeleton is always delicate

The species in this subgenus are closely allied and must be distinguished rather by the sum of their peculiarities than by any one character They occur in all countries in which Spongillidæ are found. Seven Indian species may be recognized.

1 Spongilla lacustris, *auctorum*.

Spongilla lacustris, Bowerbank, P Zool Soc London, 1863, p 441, pl xxxviii, fig 14
Spongilla lacustris, Carter, Ann Nat Hist (5) vii, p 87 (1881)
Euspongilla lacustris, Vejdovsky, in Potts's "Fresh-Water Sponges," P Ac Philad 1887, p 172
Spongilla lacustris, Potts, *ibid*, p 186, pl v, fig 1, pl vii, figs 1–6
Euspongilla lacustris, Weltner, in Zacharias's Tier- und Pflanzenwelt des Susswassers, i, p 211, figs 36–38 (1891)
Spongilla lacustris, *id*, Arch Naturg lxi (i), pp. 118, 133–135 (1895)
Spongilla lacustris, Annandale, J Linn Soc, Zool, xxx, p 245 (1908)

[I have not attempted to give a detailed synonymy of this common species There is no means of telling whether many of the earlier names given to forms or allies of *S lacustris* are actual synonyms, and it would serve no useful purpose, so far as the fauna of India is concerned, to complicate matters by referring to obscure descriptions or possible descriptions of a species only represented in India, so far as we know, by a specialized local race, to which separate references are given]

Sponge soft and easily compressed, very brittle when dry, usually consisting of a flat or rounded basal portion of no great depth and of long free cylindrical branches, which droop when removed from the water, branches occasionally absent Colour bright green when the sponge is growing in a strong light, dirty flesh-colour when it is growing in the shade. (Even in the latter case

traces of the "green corpuscles" can be detected in the cells of the parenchyma) Oscula star-shaped, of moderate size, as a rule rendered conspicuous by the furrows that radiate from them over the outer surface of the parenchyma below the external membrane, oscular collars well developed

Skeleton reticulate, loose, with definite radiating and transverse fibres held together by a small quantity of spongin, the fibres slender but not extremely so

Spicules. Skeleton-spicules smooth, sharply pointed, long, slender Flesh-spicules slender, covered with small spines, sharply pointed, nearly straight Gemmule-spicules resembling the flesh-spicules but shorter and as a rule more strongly curved, sometimes bent so as to form semicircular figures, usually pointed somewhat abruptly, their spines relatively longer than those of the flesh-spicules, often curved backwards, especially near the ends of the spicules, at which points they are often longer than elsewhere.

Gemmules usually numerous in autumn, lying free in the sponge, spherical, variable in size but usually rather large, as a rule covered with a thick granular coat in which the spicules are arranged tangentially; a horizontal layer of spicules often present in the external membrane, the granular coat and its spicules occasionally deficient No foraminal tubule, its place sometimes taken by an open, bowl-shaped chitinous structure the base of which is in continuity with the inner chitinous coat of the gemmule

S lacustris is an extremely variable species, varying in the size, proportions and shape of its spicules, in its external form and in the size and structure of the gemmule. A considerable number of varieties have been described from different parts of Europe and N America, but some of these may represent distinct but closely-allied species, descriptions of most of them will be found in Potts's "Fresh-Water Sponges." The embryology and the earlier stages of the development from the egg have been described in great detail by Evans (Quart J Micr Sci (n s) xlii, p 363 (1899)), while the anatomy and physiology are discussed by most authors who have written on these features in the Spongillidæ

TYPE —It is impossible to say who was the first authority to use the name *Spongilla lacustris* in the sense in which it is used by recent authors No type can therefore be recognized

GEOGRAPHICAL DISTRIBUTION —*S lacustris* occurs all over Europe and N America and is probably the commonest species in most parts of both continents It has also been found in Northern Asia and may occur in the Himalayan lakes and in the north-west of India

1 *a*. Subspecies **reticulata***, *Annandale*

Spongilla reticulata, Annandale, Rec Ind Mus i, p 387, pl xiv, fig 1 (1907)
Spongilla lacustris subspecies *reticulata*, *id*, P U S Mus xxxvii, p 401 (1909)

This race differs from the typical *S lacustris* in the following particulars —

(1) The branches are always compressed and anastomose freely when well developed (fig 5, p 37);
(2) the skeleton-fibres are finer;
(3) the skeleton-spicules are longer,
(4) the gemmule-spicules are longer and more slender and are never strongly bent.

As regards the form of the skeleton- and gemmule-spicules and also that of the branches the subspecies *reticulata* resembles *S alba* rather than *S. lacustris*, but owing to the fact that it

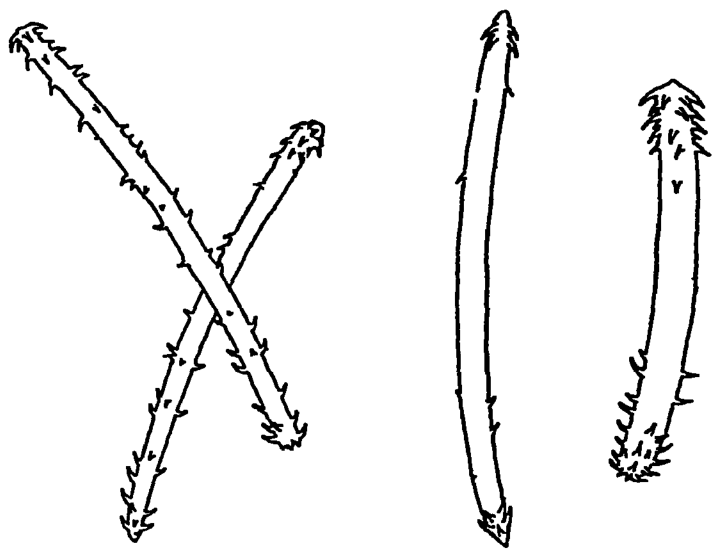


Fig 8

A=gemmule-spicules of *Spongilla lacustris* subsp *reticulata* (from type), B=gemmule-spicules of *S alba* from Calcutta both highly magnified

agrees with *S lacustris* in its profuse production of branches, in possessing green corpuscles and in its fragility, I think it should be associated with that species.

The branches are sometimes broad (fig 5, p 37), sometimes very slender In the latter condition they resemble blades of grass growing in the water

TYPE in the Indian Museum ; a co-type in the British Museum.

GEOGRAPHICAL DISTRIBUTION —All over Eastern India and Burma, also in the Bombay Presidency *Localities* —BENGAL, Port Canning, Ganges delta, Rajshahi (Rampur Bhulia) on the Ganges, 150 miles N of Calcutta (*Annandale*), Puri district, Orissa (*Annandale*), R Jharai, Sirpur, Saran district, Tirhut (*M Mackenzie*) MADRAS PRESIDENCY, Madras (town) (*J R Henderson*) BOMBAY PRESIDENCY, Igatpuri, W Ghats (*Annandale*)

BIOLOGY —This subspecies is usually found in small masses of water, especially in pools of rain-water, but Mr Mackenzie found it growing luxuriantly in the Jharai at a time of flood in September It is very abundant in small pools among the sand-dunes that skirt the greater part of the east coast of India Here it grows with great rapidity during the "rains," and often becomes desiccated even more rapidly as soon as the rain ceases As early in the autumn as October I have seen masses of the sponge attached, perfectly dry, to grass growing in the sand near the Sur Lake in Orissa They were, of course, dead but preserved a life-like appearance. Some of them measured about six inches in diameter At Port Canning the sponge grows during the rains on the brickwork of bridges over ditches of brackish water that dry up at the beginning of winter, while at Rajshahi and at Igatpuri I found it at the edges of small ponds, at the latter place in November, at the former in February Specimens taken at Madras by Dr Henderson during the rains in small ponds in the sand contained no gemmules, but these structures are very numerous in sponges examined in autumn or winter

Numerous larvæ of *Sisyra indica* (p 92) were found in this sponge at Rajshahi Unlike those obtained from *S alba*, they had a green colour owing to the green matter sucked from the sponge in their stomachs The *corralloides* phase of *Plumatella fruticosa* (p 219) was also found in *S lacustris* subsp *reticulata* at Rajshahi

So far as my experience goes, this subspecies has always a bright green colour due to the presence of "green corpuscles," even when it is growing in a pond heavily shaded by trees or under the arch of a small bridge Probably the more intense light of India enables the corpuscles to flourish in situations in which in Europe they would lose their chlorophyll

2 **Spongilla proliferens ***, *Annandale*

Spongilla cinerea, Weber (*nec* Carter), Zool Ergeb Niederl Ost-Ind vol i, pp 35, 46 (1890)
Spongilla proliferens, Annandale, J Asiat Soc Bengal, 1907, p 15, fig 1
Spongilla proliferens, *id*, Rec Ind Mus i, pp 267, 271 (1907)

Sponge forming soft, shallow cushions rarely more than 10 cm in diameter on the leaves of water-plants, or small irregular masses on their roots and stems. Colour bright green Oscula

moderate, flat, surrounded by deep, cone-shaped collars; radiating furrows and canals in the parenchyma surrounding them often deep. External pores contained normally in single cells The surface frequently covered by small rounded buds, true branches if present more or less flattened or conical, always short, as a rule absent

Skeleton loose, feebly reticulate at the base of the sponge, transverse fibres slender in the upper part of the sponge, often scarcely recognizable at its base. Very little spongin present.

Spicules. Skeleton-spicules long, smooth, sharply pointed, the length on an average at least 20 times the greatest breadth, often more. Flesh-spicules slender, gradually pointed, nearly straight, covered with minute straight or nearly straight spines Gemmule-spicules very similar, but usually a little stouter and often blunt at the ends, their spines rather longer than those on the flesh-spicules, usually more numerous near the ends than in the middle of the spicule, slightly retroverted, those at the extreme tips often so arranged as to suggest a rudimentary rotule

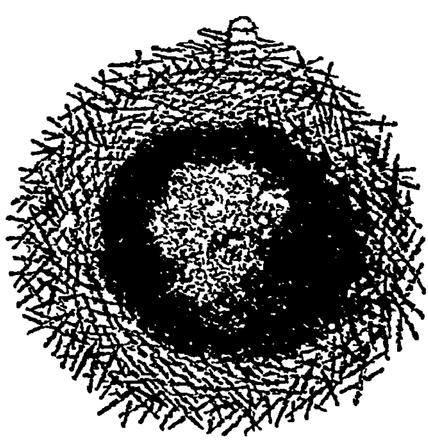


Fig 9 —Gemmule of *Spongilla proliferens* as seen in optical section (from Calcutta), × 140

Gemmules usually numerous, lying free near the base of the sponge, very variable in size, spherical, surrounded by a thick granular layer in which the spicules, which are always very numerous, are arranged tangentially, their position being more near the vertical than the horizontal, a few horizontal spicules usually present on the external surface of the gemmule, which frequently has a ragged appearance owing to some of the tangential spicules protruding further than others Foraminal tubule stout, cylindrical, usually somewhat contorted, its orifice irregular in outline Sometimes more than one foramen present

S proliferens can be distinguished from all forms of *S. lacustris* and *S alba* by the fact that its gemmules possess a foraminal tubule, from *S cinerea* it can be distinguished by its colour and its smooth skeleton-spicules, and from *S travancorica* by its free gemmules I have been enabled by the kindness of Prof Max Weber to examine specimens from Celebes and Java identified by him as *S. cinerea*, Carter, and have no doubt that they belong to my species

TYPE in the Indian Museum, a co-type in the British Museum

GEOGRAPHICAL DISTRIBUTION —All over Eastern India and Burma, also in Cochin on the west coast, Ceylon, W China; Java, Flores and Celebes *Localities* —BENGAL, Calcutta and neighbourhood (*Annandale*), Berhampore, Murshidabad district (*R E Lloyd*) ASSAM, Mangal-dai near the Bhutan frontier (*S W. Kemp*) MADRAS PRESIDENCY, Madras (town) and neighbourhood (*J. R Henderson*), Rambha, Ganjam district (*Annandale*), Bangalore, Mysore (alt *ca.* 3000 ft) (*Annandale*), Ernakulam and Trichur, Cochin (*G Mathai*) BURMA, Rangoon (*Annandale, J Coggin Brown*), Prome, Upper Burma (*J. Coggin Brown*), Kawkareik, Amherst district, Tenasserim (*Annandale*): CEYLON, between Maradankawela and Galapita-Gala, North Central Province (*Willey*) Mr J Coggin Brown has recently brought back specimens from Yunnan

BIOLOGY —*S proliferens* is usually found in ponds which never dry up; Prof Max Weber found it in small streams in Malaysia. It is common in India on the leaves of *Vallisneria* and *Limnanthemum*, on the roots of *Pistia stratiotes* and on the stems of rushes and grass So far as I have been able to discover, the life of the individual sponge is short, only lasting a few weeks.

Sexual reproduction occurs seldom or never, but reproduction by means of buds and gemmules continues throughout the year The former is a rare method of reproduction in most Spongillidæ but in this species occurs normally and constantly, the buds being often very numerous on the external surface They arise a short distance below the surface as thickenings in the strands of cells that accompany the radiating fibres of the skeleton As they grow they push their way up the fibres, forcing the external membrane outwards The membrane contracts gradually round their bases, cuts off communication between them and the parent sponge and finally sets them adrift. No hole remains when this takes place, for the membrane closes up both round the base of the bud and over the aperture whence it has emerged

The newly liberated bud already possesses numerous minute pores, but as yet no osculum, its shape exhibits considerable variation, but the end that was farthest from the parent-sponge before liberation is always more or less rounded, while the other end is flat. The size also varies considerably Some of the buds float, others sink Those that float do so either owing to their

shape, which depends on the degree of development they have reached before liberation, or to the fact that a bubble of gas is produced in their interior. The latter phenomenon only occurs when the sun is shining on the sponge at the moment they are set free, and is due to the action of the chlorophyll of the green bodies so abundant in certain of the parenchyma cells of this species If the liberation of the bud is delayed rather longer than usual, numbers of flesh-spicules are produced towards the ends of the primary skeleton-fibres and spread out in one plane so as to have a fan-like outline, in such buds the form is more flattened and the distal end less rounded than in others, and the superficial area is relatively great, so that they float more readily Those buds that sink usually fall in such a way that their proximal, flattened end comes in contact with the bottom or some suspended object, to which it adheres Sometimes, however, owing to irregularity of outline in the distal end, the proximal end is uppermost In this case it is the distal end that adheres Whichever end is uppermost, it is in the uppermost end, or as it may now be called, the upper surface, that the osculum is formed Water is drawn into the young sponge through the pores and, finding no outlet, accumulates under the external membrane, the subdermal cavity being at this stage even larger than it is in the adult sponge Immediately after adhesion the young sponge flattens itself out This process apparently presses together the water in the subdermal cavity and causes a large part of it to accumulate at one point, which is usually situated near the centre of the upper surface A transparent conical projection formed of the external membrane arises at this point, and at the tip of the cone a white spot appears What is the exact cause of this spot I have not yet been able to ascertain, but it marks the point at which the imprisoned water breaks through the expanded membrane, thus forming the first osculum Before the aperture is formed, it is already possible to distinguish on the surface of the parenchyma numerous channels radiating from the point at which the osculum will be formed to the periphery of the young sponge These channels as a rule persist in the adult organism and result from the fact that the inhalent apertures are situated at the periphery, being absent from both the proximal and the distal ends of the bud In the case of floating buds the course of development is the same, except that the osculum, as in the case of development from the gemmule in other species (see Zykoff, Biol. Centrbl. xii, p 713, 1892), is usually formed before adhesion takes place

The sponge of *S proliferens* is usually too small to afford shelter to other animals, and I have not found in it any of those commonly associated with *S carteri* and *S alba*

Owing to its small size *S proliferens* is more easily kept alive in an aquarium than most species, and its production of buds can be studied in captivity In captivity a curious

phenomenon is manifested, viz the production of extra oscula, often in large numbers This is due either to a feebleness in the currents of the sponge which makes it difficult to get rid of waste substances or to the fact that the canals get blocked The effluent water collects in patches under the external membrane instead of making its way out of the existing oscula, and new oscula are formed over these patches in much the same way as the first osculum is formed in the bud.

3 **Spongilla alba** *, *Carter*

Spongilla alba, Carter, J Bombay Asiat Soc iii, p 32, pl i, fig 4 & Ann Nat Hist (2) iv, p 83, pl iii, fig 4 (1849)
Spongilla alba, Bowerbank, P Zool Soc London, 1863, p 463 pl xxxviii, fig 15
Spongilla alba, Carter, Ann Nat Hist (5) vii, p 88 (1881)
Spongilla alba, Petr, Rozp Ceske Ak Praze, Trida, ii, pl i, figs 3-6 (1899) (text in Czech)
Spongilla alba, Annandale, Rec Ind Mus i, p 388, pl xiv, fig 2 (1907)

Sponge forming masses of considerable area, but never of more than moderate depth or thickness Surface smooth and undulating or with irregular or conical projections, sponge hard but brittle, colour white or whitish, oscula of moderate or large size, never very conspicuous; radiating furrows absent or very short; external membrane adhering to the substance of the sponge

Skeleton forming a moderately dense network of slender radiating and transverse fibres feebly held together; little spongin present, the meshes much smaller than in *S. lacustris* or *S proliferens*

Spicules Skeleton-spicules smooth, sharply pointed, slender, feebly curved Gemmule-spicules (fig 8, p 71) slender, cylindrical, blunt or abruptly pointed at the ends, feebly curved, bearing relatively long backwardly directed spines, which are usually more numerous at the ends than near the middle of the shaft Flesh-spicules very numerous in the parenchyma and especially the external membrane, as a rule considerably more slender and more sharply pointed than the gemmule-spicules, covered with straight spines which are often longer at the middle of the shaft than at the ends

Gemmules usually of large size, with a moderately thick granular layer, spicules never very numerous, often lying horizontally on the external surface of the gemmule as well as tangentially in the granular layer, no foraminal tubule, a foraminal cup sometimes present

3 *a* Var cerebellata, *Bowerbank*

Spongilla cerebellata, Bowerbank, P Zool Soc London, 1863, p 465, pl xxxviii, fig 16
Spongilla alba var. *cerebellata*, Carter, Ann Nat Hist (5) vii, p 88 (1881)

Spongilla cerebellata, Weltner, Arch Naturg lxi (1), p. 117 (1895)
Spongilla cerebellata, Kirkpatrick, Ann Nat Hist (7) xx, p 523 (1907).

This variety is distinguished from the typical form by the total absence of flesh-spicules The gemmule-spicules are also more numerous and cross one another more regularly

3 *b*. Var bengalensis *, *Annandale*. (Plate I, figs 1–3)

Spongilla lacustris var *benegalensis*, Annandale, J Asiat Soc. Bengal, 1906, p 56
Spongilla alba var *marina*, *id*, Rec Ind Mus i, p 389 (1907)

The sponge is either devoid of branches or produces irregular, compressed, and often digitate processes, sometimes of considerable length and delicacy Flesh-spicules are usually present throughout the sponge, but are sometimes absent from one part of a specimen and present in others Some of the gemmules are often much smaller than the others Perhaps this form should be regarded as a phase rather than a true variety (see p 18).

All forms of *S alba* can be distinguished from all forms of *S lacustris* by the much closer network of the skeleton and by the consequent hardness of the sponge, also by the complete absence of green corpuscles

TYPES The types of the species and of the var *cerebellata* are in the British Museum, with fragments of the former in the Indian Museum, that of var *bengalensis* is in the Indian Museum, with a co-type in London.

GEOGRAPHICAL DISTRIBUTION —India and Egypt *Localities* — BOMBAY PRESIDENCY, island of Bombay (*Carter*), Igatpuri, W. Ghats (*Annandale*) BENGAL, Calcutta, Port Canning, Ganges delta (var *bengalensis*) (*Annandale*), Garia, Salt Lakes, nr Calcutta (var *bengalensis*) (*B L Chaudhuri*); Chilka Lake, Orissa (var. *bengalensis* (*Gopal Chunder Chatterjee*) : MADRAS PRESIDENCY, Rambha, Ganjam district (*Annandale*): NIZAM'S TERRITORY, Aurangabad (*Bowerbank*, var *cerebellata*) The var. *cerebellata* has also been taken near Cairo

BIOLOGY —The typical form of the species is usually found growing on rocks or bricks at the edges of ponds, while the variety *bengalensis* abounds on grass-roots in pools and swamps of brackish water in the Ganges delta and has been found on mussel-shells (*Modiola jenkinsi*, Preston) in practically salt water in the Chilka Lake. Carter procured the typical form at Bombay on stones which were only covered for six months in the year, and "temporarily on floating objects" In Calcutta this form flourishes in the cold weather on artificial stonework in the "tanks" together with *S carteri*, *S fragilis*, *Ephydatia meyeni*, and *Trochospongilla latouchiana*

The variety *bengalensis* is best known to me as it occurs in certain ponds of brackish water at Port Canning on the Mutlah River, which connects the Salt Lakes near Calcutta with the sea

It appears in these ponds in great luxuriance every year at the beginning of the cold weather and often coats the whole edge for a space of several hundred feet, growing in irregular masses which are more or less fused together on the roots and stems of a species of grass that flourishes in such situations Apparently the tendency for the sponges to form branches is much more marked in some years than in others (see Pl I, figs 1–3) The gemmules germinate towards the end of the "rains," and large masses of sponge are not formed much before December At this season, however, the level of the water in the ponds sinks considerably and many of the sponges become dry If high winds occur, the dry sponges are broken up and often carried for considerable distances over the flat surrounding country In January the gemmules floating on the surface of the ponds form a regular scum *S alba* var *bengalensis* is the only sponge that occurs in these ponds at Port Canning, but *S lacustris*, subsp *reticulata*, is occasionally found with it on brickwork in the ditches that drain off the water from the neighbouring fields into the Mutlah estuary The latter sponge, however, perishes as these ditches dry up, at an earlier period than that at which *S alba* reaches its maximum development

The larvæ of *Sisyra indica* are commonly found in the oscula of the typical form of *S alba* as well as in those of *S lacustris* subsp *reticulata*, and *S carteri*, but the compact structure of the sponge renders it a less suitable residence for other *incolæ* than *S carteri*

In the variety *bengalensis*, as it grows in the ponds at Port Canning, a large number of arthropods, molluscs and other small animals take shelter Apart from protozoa and rotifers, which have as yet been little studied, the following are some of the more abundant inhabitants of the sponge —The sea anemone, *Sagartia schilleriana* subsp *exul* (see p 140), which frequently occurs in very large numbers in the broader canals, the free-living nematode, *Oncholaimus indicus* *, which makes its way in and out of the oscula, molluscs belonging to several species of the genus *Corbula*, which conceal themselves in the canals but are sometimes engulfed in the growing sponge and so perish, young individuals of the crab *Varuna litterata*, which hide among the branches and ramifications of the larger sponges together with several small species of prawns and the schizopod *Macropsis orientalis* †, the peculiar amphipod *Quadrivisio bengalensis* ‡, only known from the ponds at Port Canning, which breeds in little communities inside the sponge; a small isopod §, allied to

* O von Linstow, Rec. Ind Mus i, p 45 (1907)
† W M Tattersall, *ibid*, ii, p 236 (1908)
‡ T R R. Stebbing, *ibid*, i, p 160 (1907), and N Annandale, *ibid*, ii, p 107 (1908)
§ Mr Stebbing has been kind enough to examine specimens of this isopod, which he will shortly describe in the Records of the Indian Museum *S walkeri*, its nearest ally, was originally described from the Gulf of Manaar, where it was taken in a tow-net gathering (see Stebbing in Herdman's Report on the Ceylon Pearl Fisheries, pt. iv, p 31 (1905))

Sphaeroma walkeri, Stebbing, the larva of a may-fly, and those of at least two midges (Chironomidae)

The peculiarly mixed nature (marine and lacustrine) of the fauna associated with *S alba* in the ponds at Port Canning is well illustrated by this list, and it only remains to be stated that little fish (*Gobius alcockii*, *Barbus stigma*, *Haplochilus melanostigma*, *H panchax*, etc) are very common and feed readily on injured sponges. They are apparently unable to attack a sponge so long as its external membrane is intact, but if this membrane is broken, they swarm round the sponge and devour the parenchyma greedily In fresh water one of these fishes (*Gobius alcockii*, see p 94) lays its eggs in sponges

The chief enemy of the sponges at Port Canning is, however, not an animal but a plant, viz., a green filamentous alga which grows inside the sponge, penetrating its substance, blocking up its canals and so causing it to die Similar algæ have been described as being beneficial to the sponges in which they grow †, but my experience is that they are deadly enemies, for the growth of such algæ is one of the difficulties which must be fought in keeping sponges alive in an aquarium The alga that grows in *S alba* often gives it a dark green colour, which is, however, quite different from the bright green caused by the presence of green corpuscles The colour of healthy specimens of the variety *bengalensis* is a rather dark grey, which appears to be due to minute inorganic particles taken into the cells of the parenchyma from the exceedingly muddy water in which this sponge usually grows If the sponge is found in clean water, to whichever variety of the species it belongs, it is nearly white with a slight yellowish tinge Even when the typical form is growing in close proximity to *S proliferens*, as is often the case, no trace of green corpuscles is found in its cells

4 Spongilla cinerea *, *Carter*

Spongilla cinerea, Carter, J Bombay Soc iii, p 30, pl i, fig 5, & Ann Nat Hist (2) iv, p 82, pl iii, fig 6 (1849)
Spongilla cinerea, Bowerbank, P Zool Soc London, 1863, p 468, pl xxxviii, fig 19
Spongilla cinerea, Carter, Ann Nat Hist (5) vii, p 263 (1881)

Sponge forming large, flat sheets, never more than a few millimetres in thickness, without a trace of branches, compact but very friable, of a dark greyish colour, oscula small and inconspicuous or moderately large, never prominent, membrane adhering closely to the sponge

Skeleton with well-defined but slender radiating fibres, which contain very little spongin, transverse fibres close together but consisting for the most part of one or two spicules only

† See M. and A Weber in M. Weber's Zool Ergeb Niederl Ost-Ind vol i, p 48, pl v (1890)

Spicules Skeleton-spicules short, slender, sharply pointed, minutely serrated or irregular in outline, almost straight Gemmule-spicules very small, rather stout, cylindrical, pointed, covered with relatively long and stout spines which are either straight or directed towards the ends of the spicule Flesh-spicules fairly numerous in the external membrane but by no means abundant in the parenchyma, very slender, gradually pointed, covered uniformly with minute but distinct spines

Gemmules very small, only visible to the naked eye as minute specks, as a rule numerous, free in the substance of the sponge, each provided with a slender foraminal tubule and covered with a thick granular coat in which the gemmule-spicules are arranged almost horizontally, a horizontal layer of spicules also present on the external surface of the gemmule, gemmule-spicules very numerous.

This sponge is easily distinguished from its Indian allies by the form of its skeleton-spicules, which are, as Bowerbank expresses it, "subspined", that it to say, under a high power of

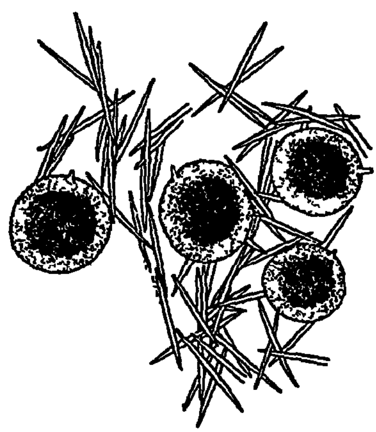


Fig 10 —Gemmules and fragment of the skeleton of *Spongilla cinerea* (from type specimen), × 35

the microscope their outline appears to be very minutely serrated, although under a low power they seem to be quite smooth The spicules also are smaller than those of *S alba*, the only species with which *S cinerea* is likely to be confused, and the gemmule has a well-developed foraminal tubule, the skeleton is much closer than in *S proliferens*

Type in the British Museum, a piece in the Indian Museum

Geographical Distribution —*S cinerea* is only known from the Bombay Presidency Carter obtained the original specimens at Bombay and the only ones I have found were collected at Nasik, which is situated on the eastern slopes of the Western Ghats, about 90 miles to the north-east

Biology —Carter's specimens were growing on gravel, rocks and stones at the edge of "tanks," and were seldom covered for more than six months in the year. Mine were on the sides of a

stone conduit built to facilitate bathing by conveying a part of the water of the Godaveri River under a bridge. They were accompanied by *Spongilla indica* and *Corvospongilla lapidosa* (the only other sponges I have found in running water in India) and in the month of November appeared to be in active growth

5 **Spongilla travancorica** *, *Annandale*

Spongilla travancorica, Annandale, Rec Ind Mus III, p. 101, pl. XII, fig 1 (1909)

Sponge small, encrusting, without branches, hard but brittle, its structure somewhat loose, colour dirty white Dermal membrane in close contact with the skeleton, pores and oscula inconspicuous. Surface minutely hispid, smooth and rounded as a whole.

Skeleton consisting of moderately stout and coherent radiating fibres and well-defined transverse ones; a number of horizontal megascleres present at the base and surface, but not arranged in any definite order No basal membrane

A B

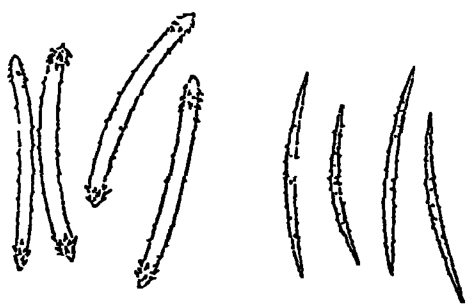


Fig 11.—Microscleres of *Spongilla travancorica*
A=Gemmule-spicules, B=flesh-spicules (from type specimen), × 240.

Spicules Skeleton-spicules smooth, pointed at either end, moderately stout, straight or curved, sometimes angularly bent; curvature usually slight Free microscleres abundant in the dermal membrane, slender, nearly straight, gradually and sharply pointed, profusely ornamented with short straight spines, which are much more numerous and longer at the middle than near the ends Gemmule-spicules stouter and rather longer, cylindrical, terminating at each end in a sharp spine, ornamented with shorter spines, which are more numerous and longer at the ends than at the middle, at the ends they are sometimes directed backwards without, however, being curved

Gemmules firmly adherent to the support of the sponge, at the base of which they form a layer one gemmule thick, each provided with at least one foraminal tubule, which is straight and conical two tubules, one at the top and one at one side, usually present Granular layer well developed Spicules arranged irregularly in this layer, as a rule being more nearly vertical than horizontal but pointing in all directions, not confined externally by a membrane, no external layer of horizontal spicules.

Measurements of Spicules and Gemmules.

Length of skeleton-spicules .	0 289–0 374 mm
Greatest diameter of skeleton-spicules	0 012–0 016 „
Length of free microscleres	0 08 –0·096 „
Greatest diameter of free microscleres	0 002 mm
Length of gemmule-spicules	0 1 –0 116 „
Diameter of gemmule-spicule	0 008 mm
„ „ gemmule	0 272–0 374 „

This species is easily distinguished from its allies of the sub-genus *Euspongilla* by its adherent gemmules with their (usually) multiple apertures and rough external surface

TYPE in the collection of the Indian Museum.

HABITAT Backwater near Shasthancottah, Travancore, in slightly brackish water; on the roots of shrubs growing at the edge; November, 1908 (*Annandale*)

The specimens were dead when found.

6 **Spongilla hemephydatia** *, *Annandale*

Spongilla hemephydatia, Annandale, Rec Ind Mus iii, p 275 (1909)

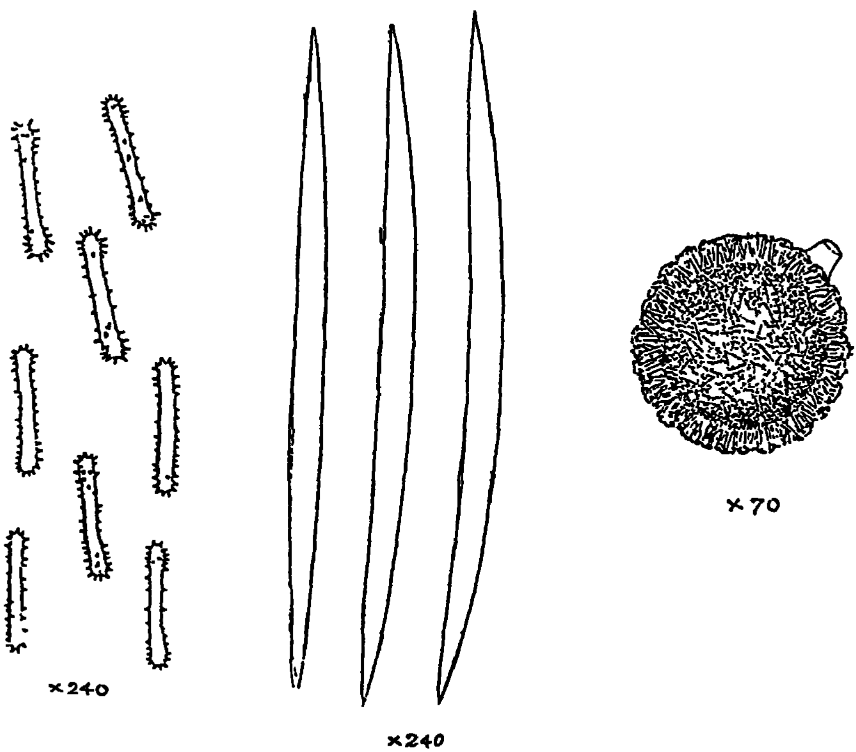


Fig 12 —Gemmule and spicules of *Spongilla hemephydatia* (from type specimen)

Sponge soft, fragile, amorphous, of a dirty yellow colour, with large oscula which are not conspicuously raised above the

surface but open into very wide horizontal channels in the substance of the sponge. The oscular collars are fairly well developed, but the subepidermal space is not extensive

Skeleton diffuse, consisting of very fine radiating fibres, which are crossed at wide and irregular intervals by still finer transverse ones, very little chitinoid substance present

Spicules Skeleton-spicules smooth, slender, sharply pointed at both ends, nearly straight No true flesh-spicules Gemmule-spicules straight or nearly so, cylindrical, or constricted in the middle, obscurely pointed or blunt, clothed with short, sharp, straight spines, which are very numerous but not markedly longer at the two ends, these spicules frequently found free in the parenchyma

Gemmules numerous, small, free, spherical, yellow, with a well-developed granular coat (in which the spicules are arranged almost horizontally) and external to it a fine membrane which in preserved specimens becomes puckered owing to unequal contraction, each gemmule with a single aperture provided with a straight, rather wide, but very delicate foraminal tubule

Measurements of Spicules and Gemmules

Length of skeleton-spicule	0 313 mm.
Breadth of skeleton-spicule	0 012 ,,
Length of gemmule-spicule	0 062 ,,
Breadth of gemmule-spicule	0 004 ,,
Diameter of gemmule	0 313–0 365 mm

This sponge in its general structure bears a very close resemblance to *Spongilla crateriformis*

TYPE in the collection of the Indian Museum.

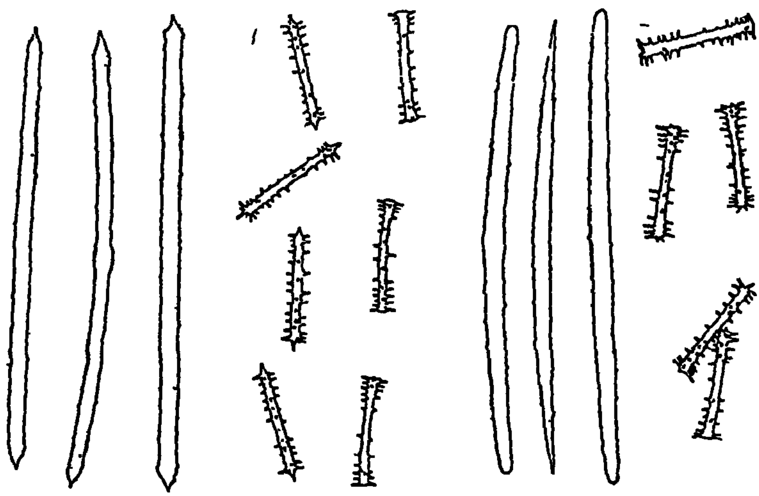
HABITAT Growing on weeds at the edge of the Sur Lake, Orissa, October 1908 Only one specimen was taken, together with many examples of *S lacustris* subsp. *reticulata*, *S. carteri* and *S crassissima*

7 Spongilla crateriformis * (*Potts*).

Meyenia crateriforma, Potts, P Ac Philad 1882, p 12
Meyenia crateriformis, *id*, *ibid* 1887, p 228, pl v, fig 6, pl x, fig 5
?*Ephydatia crateriformis*, Hanitsch, Nature, li, p 511 (1895)
Ephydatia crateriformis, Weltner, Arch Naturg lxi (i), pp 122, 134 (1895)
? *Ephydatia crateriformis*, Hanitsch, Irish Natural iv, p 125, pl iv, fig 5 (1895)
Ephydatia indica, Annandale, J Asiat Soc Bengal, 1907, p 20 (figures poor)
Ephydatia indica, *id*, Rec Ind Mus i, pp 272, 279, 388, 391 (1907)
Ephydatia crateriformis, Scharff, European Animals, p 34 (1907)
Ephydatia crateriformis, Annandale, P U S Mus xxxvii, p 402, fig 1 (1909)

Sponge very fragile, forming soft irregular masses on the roots and stems of water-plants, between which it is sometimes stretched as a delicate film, or thin layers or cushions on flat surfaces Oscula large, flat, circular, or of irregular shape, opening into broad horizontal canals, which at their distal end are superficial and often covered by the external membrane only Colour white, yellowish, greyish, or blackish.

Skeleton very delicate; radiating fibres rarely consisting of more than two parallel spicules; transverse fibres far apart, frequently consisting of single spicules, very little spongin present



A. B

Fig 13 —Spicules of *Spongilla crateriformis*

A From specimen taken in July in a tank on the Calcutta maidan B From type specimen of *Ephydatia indica* taken in the Indian Museum tank in winter Both figures × 240

Spicules Skeleton-spicules feebly curved, slender, as a rule irregular in outline, sometimes almost smooth, the ends as a rule sharply pointed, often constricted off and expanded so as to resemble spear-heads, occasionally blunt. No true flesh-spicules. Gemmule-spicules often free in the parenchyma, cylindrical, slender, very variable in length in different sponges, straight or nearly so, as a rule with an irregular circle of strong straight or recurved spines at either end resembling a rudimentary rotule, and with shorter straight spines scattered on the shaft, sometimes without the rudimentary rotule, either truncate at the ends or terminating in a sharp spine

Gemmules small, free, each surrounded by a thick granular layer in which the spicules stand upright or nearly so, and covered externally by a delicate but very distinct chitinous membrane; no

horizontal spicules; foramen situated at the base of a crater-like depression in the granular coat, which is sometimes raised round it so as to form a conspicuous rampart; a short, straight foraminal tubule

The shape of the spicules is extremely variable, and sponges in which they are very different occur in the same localities and even in the same ponds. It is possible that the differences are directly due to slight changes in the environment, for in one pond in Calcutta a form with *Spongilla*-like gemmule-spicules appears to replace the typical form, which is common in winter, during the hot weather and "rains." I have not, however, found this to be the case in other ponds Perhaps *S hemephydatia* will ultimately prove to be a variety of this very variable species, but its smooth and regular skeleton-spicules and short-spined gemmule-spicules afford a ready method of distinguishing it from *S crateriformis* The two sponges are easily distinguished from all others in the subgenus *Euspongilla* by the upright and regular arrangement of their gemmule-spicules, for although in *S. proliferens* and *S travancorica* some of the gemmule-spicules are nearly vertical, their arrangement is always irregular, a large proportion of the spicules make an acute angle with the inner coat of the gemmule and a few as a rule lie parallel to it. The systematic position of *S crateriformis* is almost exactly intermediate between *Euspongilla* and *Ephydatia*, to which genus it has hitherto been assigned I think, however, that taking into consideration its close relationship to *S. hemephydatia*, it is best to assign it to *Spongilla* as its rudimentary rotules never form distinct disks. I have examined some of Potts's original specimens from different American localities and can detect no constant difference between them and Indian specimens

Types in the United States National Museum; co-types in Calcutta.

Geographical Distribution —This sponge was originally described from North America (in which continent it is widely distributed) and has been recorded from the west of Ireland with some doubt. In India and Burma it is widely distributed. Bengal, Calcutta and neighbourhood (*Annandale*), Sonarpur, Gangetic delta (*Annandale*), Bombay Presidency, Igatpuri Lake, W Ghats (altitude *ca* 2,000 feet) (*Annandale*); Madras Presidency, neighbourhood of Madras town (*J R Henderson*); Museum compound, Egmore (Madras town) (*Annandale*), near Bangalore (alt *ca* 3,000 ft), Mysore State (*Annandale*); Ernakulam, Cochin (*G Mathai*) Burma Kawkareik interior of Amherst district, Tenasserim, and the Moulmein waterworks in the same district (*Annandale*) *

* Mr O A Paiva, Assistant in the Indian Museum, has lately (March 31st, 1911) obtained specimens of *S crateriformis* in a small pond of fresh water on Ross Island in the Andaman group The existence of this widely distributed species on an oceanic island is noteworthy

BIOLOGY —*S crateriformis* flourishes in Calcutta throughout the year Here it is usually found adhering to the roots of water-plants, especially *Pistia* and *Limnanthemum* In the case of the former it occurs at the surface, in that of the latter at the bottom. When growing near the surface or even if attached to a stone at the bottom in clear water, it is invariably of a pale yellowish or greyish colour When growing on the roots of *Limnanthemum* in the mud of the Gangetic alluvium, however, it is almost black, and when growing in the reddish muddy waters of the tanks round Bangalore of a reddish-brown colour This appears to be due entirely to the absorption of minute particles of inorganic matter by the cells of the parenchyma It black sponges of the species are kept alive in clean water, they turn pure white in less than a week, apparently because these particles are eliminated. When growing on stones the sponge, as found in India, often conforms exactly with Potts's description "a filmy grey sponge, branching off here and there yet with a curious lack of continuity ."

The wide efferent canals of this sponge afford a convenient shelter to small crustacea, and the isopod *Tachæa spongillicola*, Stebbing (see p 94), is found in them more abundantly than in those of any other sponge This is especially the case when the sponge is growing at the bottom On the surface of the sponge I have found a peculiar protozoon which resembles the European *Trichodina spongillæ* in general struture but belongs, I think, to a distinct species, if not to a distinct genus

Subgenus B EUNAPIUS, *J E Gray*

Eunapius, J E Gray (*partim*), P Zool Soc London, 1867, p 552

Spongilla (*s str*), Vejdovsky, in Potts's "Fresh-Water Sponges," P Ac. Philad 1887, p 172

Spongilla (*s str*), Weltner, in Zacharias's Tier- und Pflanzenwelt des Susswassers, i, p 214 (1891)

Spongilla (*s str*), Annandale, Zool Jahrb, Syst xxvii, p 559 (1909)

TYPE, *Spongilla carteri*, Carter

Spongillæ in which the gemmules are covered with layers of distinct polygonal air-spaces with chitinous walls

The gemmules are usually fastened together in groups, which may either be free in the sponge or adhere to its support as a "pavement layer", sometimes, however, they are not arranged in this manner, but are quite independent of one another The skeleton is usually delicate, sometimes very stout (*e g*, in *S nitens*, Carter)

The term *Eunapius* here used is not quite in the original sense, for Gray included under it Bowerbank's *Spongilla paupercula* which is now regarded as a form of *S lacustris* His description, nevertheless, fits the group of species here associated except in one particular, viz, the smoothness of the gemmule-spicules to which he refers, for this character, though a feature of *S carteri*, is no

found in certain closely allied forms The use of "*Spongilla*" in a double sense may be avoided by the adoption of Gray's name.

The subgenus *Eunapius* is, like *Euspongilla*, cosmopolitan. It is not, however, nearly so prolific in species Four can be recognized in India, two of which range, in slightly different forms, as far north as Europe, one of them also being found in North America, Northern Asia, and Australia

8 **Spongilla carteri** * *Carter* (*Bowerbank*, in litt). (Plate II fig 1)

Spongilla friabilis?, Carter (*nec* Lamarck), J Bombay Asiat Soc iii, p 31, pl i, fig 3 (1849), & Ann Nat Hist (2) iv, p 83, pl ii fig 3 (1849)
Spongilla carteri, Carter, Ann Nat Hist (3) iii, p 334, pl viii, figs 1-7 (1859)
Spongilla carteri, Bowerbank, P Zool Soc London, 1863, p 469, pl xxxviii, fig 20
Eunapius carteri, J E Gray, *ibid* 1867, p 552
Spongilla carteri, Carter, Ann Nat Hist (5) vii, p 86 (1881)
Spongilla carteri, *id*, *ibid* x, p 369 (1882)
Spongilla carteri, Potts, P Ac Philad 1887, p 194
Spongilla carteri, Weltner, Arch Naturg lxi (i), pp 117, 134 (1895)
Spongilla carteri, Kirkpatrick, P Zool Soc London, 1906 (i), p 219, pl xv, figs 3, 4 (? figs 1, 2)
Spongilla carteri, Annandale, J Asiat Soc Bengal, 1906, p 188, pl i, fig 1
Spongilla carteri, Willey, Spolia Zeyl iv, p 184 (1907)
Spongilla carteri, Annandale, *ibid* vii, p 63, pl 1, fig 1 (1910).

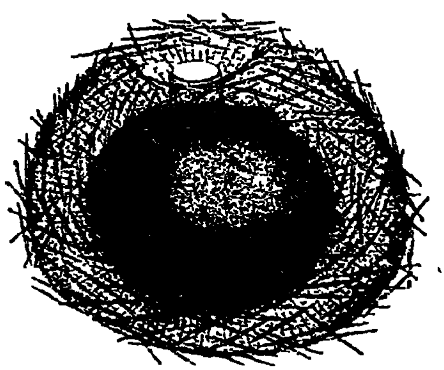


Fig 14 —Gemmule of *Spongilla carteri* (from Calcutta), as seen in optical section, × 140

Sponge massive, as a rule with the surface smooth and rounded, occasionally bearing irregular ridges, which may even take the form of cockscombs, the oscula large, rounded, conspicuous but not raised above the surface of the sponge, leading into broad vertical

canals, the lateral canals, except in the immediate vicinity of the central vertical ones, not very broad, the oscular collars extending for a considerable distance over the oscula in living or well-preserved specimens, never standing out from the surface; the oscula never surrounded by radiating furrows. The inhalent pores surrounded externally by unmodified cells of the external membrane Colour greyish, sometimes with a flush of green on the external surface

The sponge has a peculiarly strong and offensive smell

Skeleton fairly compact, with well-developed radiating fibres, the transverse fibres splayed out at either end so that they sometimes resemble a pair of fans joined together by the handles (fig. 3, p 33). A moderate amount of spongin present

Spicules Skeleton-spicules smooth, pointed, nearly straight, never very stout but somewhat variable in exact proportions Gemmule-spicules similar but much smaller (There are no true flesh-spicules, but immature skeleton-spicules may easily be mistaken for them)

Gemmules as a rule numerous, spherical or flattened at the base, variable in size, each covered by a thick coat consisting of several layers of relatively large polygonal air-spaces A single aperture surrounded by a crater-like depression in the cellular coat and provided with a foraminal tubule resembling an inverted bottle in shape (This tubule, which does not extend beyond the surface of the cellular coat, is liable to be broken off in dried specimens) The spicules variable in quantity, arranged irregularly among the spaces of the cellular coat and usually forming a sparse horizontal layer on its external surface. Each gemmule contained in a cage of skeleton-spicules, by the pressure of which it is frequently distorted.

8 *a* Var. mollis*, nov.

This variety is characterized by a paucity of skeleton-spicules. The sponge is therefore soft and so fragile that it usually breaks in pieces if lifted from the water by means of its support Owing to the paucity of skeleton-spicules, which resemble those of the typical form individually, the radiating and transverse fibres are extremely delicate

Common in Calcutta

8 *b* Var cava*, nov

This variety is characterized by the fact that the oscula open into broad horizontal canals, the roof of which is formed by a thin layer of parenchyma and skeleton or, in places, of the external membrane only The skeleton is loose and fragile, and the living sponge has a peculiar glassy appearance. In spirit the colour is yellowish, during life it is greenish or white

Taken at Bombay, November, 1907

8 *c*. Var. lobosa*, nov.

The greater part of the sponge in this variety consists of a number of compressed but pointed vertical lobes, which arise from a relatively shallow, rounded base, in which the oscula occur. The dried sponge has a yellowish colour.

Apparently common in Travancore.

I cannot distinguish these three "varieties"† from the typical form as distinct species; indeed, their status as varieties is a little doubtful in two cases out of the three. Var. *cava* appears to be a variety in the strict sense of the word (see p. 18), for it was found on the island of Bombay, the original locality of the species, growing side by side with the typical form. Var. *lobosa*, however, should perhaps be regarded as a subspecies rather than a variety, for I have received specimens from two localities in the extreme south-west of India and have no evidence that the typical form occurs in that part of the country. Evidence, however, is rather scanty as regards the occurrence of freshwater sponges in S. India. Var. *mollis*, again, may be a phase directly due to environment. It is the common form in the ponds of certain parts (*e. g.* in the neighbourhood of the Maidan and at Alipore) of the Calcutta municipal area, but in ponds in other parts (*e. g.* about Belgatchia) of the same area, only the typical form is found. It is possible that the water in the former ponds may be deficient in silica or may possess some other peculiarity that renders the production of spicules difficult for *S. carteri*, but this seems hardly probable, for *S. crassissima*, a species with a rather dense siliceous skeleton, flourishes in the same ponds. I have noticed that in ponds in which the aquatic vegetation is luxuriant and such genera of plants as *Pistia* and *Limnanthemum* flourish, there is always a tendency for *S. carteri* to be softer than in ponds in which the vegetation is mostly cryptogamic, and in Calcutta those parts of the town in which sponges of this species produce most spicules are those in which a slight infiltration of brackish water into the ponds may be suspected; but in the interior of India, in places where the water is absolutely fresh, hard specimens seem to be the rule rather than the exception.

S. carteri is closely related to *S. nitens*, Carter (Africa, and possibly S. America), but differs from that species in its comparatively slender, sharp skeleton-spicules and smooth gemmule-spicules. It may readily be distinguished from all other Indian freshwater sponges by its large, deep, round oscula, but this feature is not so marked in var. *lobosa* as in the other forms. The typical form and

† The only complete European specimen of the species I have seen differs considerably in outward form from any Indian variety, consisting of a flat basal area from which short, cylindrical turret-like branches arise. This specimen is from Lake Balaton in Hungary and was sent me by Prof. von Daday de Dees of Buda-Pesth.

var *mollis* grow to a larger size than is recorded for any other species of the family I possess a specimen of the typical form from the neighbourhood of Calcutta which measures 30 × 27 cm in diameter and 19 5 cm in depth, and weighs (dry) 24¾ oz The base of this specimen, which is solid throughout, is nearly circular, and the general form is mound-shaped Another large specimen from Calcutta is in the form of an irregular wreath, the greatest diameter of which is 34 cm This specimen weighs (dry) 16¼ oz Both these specimens probably represent the growth of several years

TYPES —The types of the varieties *mollis*, *cava* and *lobosa* are in the collection of the Indian Museum I regard as the type of the species the specimen sent by Carter to Bowerbank and by him named *S carteri*, although, owing to some confusion, Carter's description under this name appeared some years before Bowerbank's This specimen is in the British Museum, with a fragment in the Indian Museum.

GEOGRAPHICAL DISTRIBUTION —The range of the species extends westwards to Hungary, southwards to Mauritius and eastwards to the island of Madura in the Malay Archipelago; a specimen from Lake Victoria Nyanza in Central Africa has been referred to it by Kirkpatrick (P Zool Soc London, 1906 (i), p 219), but I doubt whether the identification is correct In India *S carteri* is by far the most universally distributed and usually much the commonest freshwater sponge; it is one of the only two species as yet found in Ceylon Specimens are known from the following localities —PUNJAB, Lahore (*J. Stephenson*) BOMBAY PRESIDENCY, island of Bombay (*Carter*, *Kirkpatrick*, *Annandale*); Igatpuri, W Ghats (alt *ca* 2,000 ft.) (*Annandale*) UNITED PROVINCES (plains), Agra (*Kirkpatrick*); Lucknow: HIMALAYAS, Bhim Tal, Kumaon (alt 4,500 ft) (*Annandale*), Tribeni, Nepal (*Hodgart*) BENGAL, Calcutta and neighbourhood; Rajshahi (Rampur Bhulia) on the R Ganges about 150 miles N of Calcutta (*Annandale*), Berhampur, Murshidabad district (*R E Lloyd*). Pusa, Darbbhanga district (*Bainbrigge Fletcher*), Siripur, Saran district, Tirhut (*M Mackenzie*), Puri and the Sur Lake, Orissa (*Annandale*) MADRAS PRESIDENCY, near Madras town (*J R Henderson*), Madura district (*R Bruce Foote*), Bangalore (*Annandale*) and Worgaum, Mysore State (2,500–3,000 ft), Ernakulam and Trichur, Cochin (*G Mathai*), Trivandrum and the neighbourhood of C Comorin, Travancore (var *lobosa*) (*R S N Pillay*) BURMA, Kawkareik, interior of Amherst district, Tenasserim (*Annandale*), Rangoon (*Annandale*), Bhamo, Upper Burma (*J Coggin Brown*) CEYLON, Peradeniya (*E E Green*), outlet of the Maha Rambaikulam between Vavuniya and Mamadu, Northern Province (*Willey*); Horowapotanana, between Trincomalee and Anuradhapura, North-Central Province (*Willey*)

BIOLOGY —*S carteri* usually grows in ponds and lakes, I have never seen it in running water Mr Mackenzie found it on the walls of old indigo wells in Tirhut.

The exact form of the sponge depends to some extent on the

forces acting on it during life. At Igatpuri, for instance, I found that specimens attached to the stems of shrubs growing in the lake and constantly swayed by the wind had their surface irregularly reticulated with high undulating ridges, while those growing on stones at the bottom of a neighbouring pond were smooth and rounded

Sponges of this species do not shun the light.

In Calcutta *S. carteri* flourishes during the cold weather (November to March) By the end of March many specimens that have attached themselves to delicate stems such as those of the leaves of *Limnanthemum*, or to the roots of *Pistia stratiotes*, have grown too heavy for their support and have sunk down into the mud at the bottom of the ponds, in which they are quickly smothered Others fixed to the end of branches overhanging the water or to bricks at the edge have completely dried up. A large proportion, however, still remain under water, but even these begin to show signs of decay at this period. Their cells migrate to the extremities of the sponge, leaving a mass of gemmules in the centre, and finally perish.

Few sponges exist in an active condition throughout the hot weather. The majority of those that do so exhibit a curious phenomenon Their surface becomes smoothly rounded and they have a slightly pinkish colour; the majority of the cells of their parenchyma, if viewed under a high power of the microscope, can be seen to be gorged with very minute drops of liquid. This liquid is colourless in its natural condition, but if the sponge is plunged into alcohol the liquid turns of a dark brown colour which stains both the alcohol and the sponge almost instantaneously. Probably the liquid represents some kind of reserve food-material. Even in the hot weather a few living sponges of the species may be found that have not this peculiarity, but, in some ponds at any rate, the majority that survive assume the peculiar summer form, which I have also found at Lucknow.

Reproduction takes place in *S carteri* in three distinct ways, two of which may be regarded as normal, while the third is apparently the result of accident If a healthy sponge is torn into small pieces and these pieces are kept in a bowl of water, little masses of cells congregate at the tips of the radiating fibres of the skeleton and assume a globular form At first these cells are homogeneous, having clear protoplasm full of minute globules of liquid. The masses differ considerably in size but never exceed a few millimetres in diameter In about two days differentiation commences among the cells; then spicules are secreted, a central cavity and an external membrane formed, and an aperture, the first osculum, appears in the membrane In about ten days a complete young sponge is produced, but the details of development have not been worked out.

The most common normal form of reproduction is by means of gemmules, which are produced in great numbers towards the end of the cold weather. If small sponges are kept alive in an aquarium even at the beginning of the cold weather, they begin

to produce gemmules almost immediately, but these gemmules although otherwise perfect, possess few or no gemmule-spicules. If the sponge becomes desiccated at the end of the cold weather and is protected in a sheltered place, some or all of the gemmules contained in the meshes of its skeleton germinate *in situ* as soon as the water reaches it again during the "rains." It is by a continuous or rather periodical growth of this kind, reassumed season after season, that large masses of sponge are formed. In such masses it is often possible to distinguish the growth of the several years, but as a rule the layers become more or less intimately fused together, for no limiting membrane separates them. A large proportion of the gemmules are, however, set free and either float on the surface of the water that remains in the ponds or are dried up and carried about by the wind. In these circumstances they do not germinate until the succeeding cold weather, even if circumstances other than temperature are favourable; but as soon as the cold weather commences they begin to produce new sponges with great energy.

Sexual reproduction, the second normal form, takes place in *S. carteri* mainly if not only at the approach of a change of season, that is to say about March, just before the hot weather commences, and about November, just as the average temperature begins to sink to a temperate level. At these seasons healthy sponges may often be found full of eggs and embryos, which lie in the natural cavities of the sponge without protecting membrane.

In the ponds of Calcutta a large number of animals are found associated in a more or less definite manner with *Spongilla carteri*. Only one, however, can be described with any degree of certainty as being in normal circumstances an enemy, namely the larva of *Sisyra indica*,* and even in the case of this little insect it is doubtful how far its attacks are actually injurious to the sponge. The larva is often found in considerable numbers clinging to the oscula and wide efferent canals of *S. carteri*, its proboscis inserted into the substance of the sponge. If the sponge dies and the water becomes foul the larvæ swim or crawl away. If the sponge dries up, they leave its interior (in which, however, they sometimes remain for some days after it has become dry) and pupate in a silken cocoon on its surface. Hence they emerge as perfect insects after about a week.

An animal that may be an enemy of *S. carteri* is a flat-worm (an undescribed species of *Planaria*) common in its larger canals and remarkable for the small size of its pharynx. The same worm, however, is also found at the base of the leaves of bulrushes and in other like situations, and there is no evidence that it actually feeds on the sponge. Injured sponges are eaten by the prawn *Palæmon lamarrei*, which, however, only attacks them when the dermal membrane is broken. A *Tanypus* larva (Chironomid

* Needham, Rec. Ind. Mus. iii, p. 206 (1909).

Diptera) that makes its way though the substance of the sponge may also be an enemy; it is commoner in decaying than in vigorous sponges.

The presence of another Chironomid larva (*Chironomus*, sp.) appears to be actually beneficial. In many cases it is clear that this larva and the sponge grow up together, and the larva is commoner in vigorous than in decayed sponges. Unlike the *Tanypus* larva, it builds parchment-like tubes, in which it lives, on the surface of the sponge. The sponge, however, often grows very rapidly and the larva is soon in danger of being engulfed in its substance. The tube is therefore lengthened in a vertical direction to prevent this catastrophe and to maintain communication with the exterior. The process may continue until it is over an inch in length, the older part becoming closed up owing to the pressure of the growing sponge that surrounds it. Should the sponge die, the larva lives on in its tubes without suffering, and the ends of tubes containing larvæ may sometimes be found projecting from the worn surface of dead sponges. The larva does not eat the sponge but captures small insects by means of a pair of legs on the first segment of its thorax. In so doing it thrusts the anterior part of its body out of the tube, to the inner surface of which it adheres by means of the pair of false legs at the tip of the abdomen. This insect, which is usually found in the variety *mollis*, appears to do good to the sponge in two ways—by capturing other insects that might injure it and by giving support to its very feeble skeleton.

A precisely similar function, so far as the support of the sponge is concerned, is fulfilled by the tubular zooecia of a phase of the polyzoon *Plumatella fruticosa* (see p. 218) which in India is more commonly found embedded in the substance of *S. carteri* than in that of any other species, although in Great Britain it is generally found in that of *S. lacustris*, which is there the commonest species of freshwater sponge.

Another animal that appears to play an active part in the œconomy of the sponge is a peculiar little worm (*Chætogaster spongillæ*) also found among the zooecia of *Plumatella* and belonging to a widely distributed genus of which several species are found in association with pond-snails. *Chætogaster spongillæ* often occurs in enormous numbers in dead or dying sponges of *S. carteri*, apparently feeding on the decaying organic matter of the sponge and assisting by its movements in releasing numerous gemmules. In so doing it undoubtedly assists in the dissemination of the species.

Major J. Stephenson (Rec. Ind. Mus. v, p. 233) has recently found two other species of oligochætes inhabiting *S. carteri* var. *lobosa* from Travancore. Both these species, unlike *Chætogaster spongillæ*, belong to a genus that is vegetarian in habits. One of them, *Nais pectinata*, has not yet been found elsewhere, while the other, *Nais communis*, has a very wide distribution. The latter, however, occurs in the sponge in two forms—one with eyes, the other totally blind. The blind form (*N. communis* var. *cæca*) has

only been found in this situation, but the other (var *punjabensis*) lives free as well as in association with the sponge, in which the blind form was the commoner of the two

The majority of the animals found in association with *S carteri* gain shelter without evident assistance to the sponge This is the case as regards the little fish (*Gobius alcocki*), one of the smallest of the vertebrates (length about ½ inch), which lays its eggs in the patent oscula, thus securing for them a situation peculiarly favourable to their development owing to the constant current of water that passes over them In the absence of sponges, however this fish attaches its eggs to the floating roots of the water-plant *Pistia stratiotes* Numerous small crustacea* also take temporary or permanent refuge in the cavities of *S carteri*, the most noteworthy among them being the Isopod *Tachæa spongillicola* †, the adults of which are found in the canal of this and other sponges, while the young cling to the external surface of the carapace of *Palæmon lamarrei* and other small prawns Many worms and insects of different kinds also enter the canals of *S carteri*, especially when the sponge is becoming desiccated, from half-dry sponges numerous beetles and flies may be bred, notably the moth-fly *Psychoda nigripennis* ‡, of which enormous numbers sometimes hatch out from such sponges

As the sponge grows it frequently attaches itself to small molluscs such as the young of *Vivipara bengalensis*, which finally become buried in its substance and thus perish Possibly their decaying bodies may afford it nourishment, but of the natural food of sponges we know little *S carteri* flourishes best and reaches its largest size in ponds used for domestic purposes by natives of India, and thrives in water thick with soap-suds. It is possible, though direct proof is lacking, that the sponge does good in purifying water used for washing the clothes, utensils, and persons of those who drink the same water, by absorbing decaying animal and vegetable matter from it

Various minute algæ are found associated with *S carteri*, but of these little is yet known The green flush sometimes seen on the surface of the typical form is due to the fact that the superficial cells of the parenchyma contain green corpuscles These, however, are never very numerous and are not found in the inner parts of the sponge, perhaps owing to its massive form It is noteworthy that these green bodies flourish in large numbers throughout the substance of sponges of *S proliferens*, a species always far from massive, growing in the same ponds as *S carteri*

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* According to the late Rai Bahadur R B Sanyal, freshwater sponges are called in Bengali "shrimps' nests" From his description it is evident that he refers mainly to *S carteri* (see Hours with Nature, p 46, Calcutta 1896)

† Stebbing, J Linn Soc xxx, p 40, Annandale, Rec Ind Mus i, p 279

‡ Brunetti, Rec Ind Mus ii, p 376 (1908)

9 **Spongilla fragilis**, *Leidy*

Spongilla fragilis, Leidy, P Ac Philad 1851, p 278
Spongilla lordii, Bowerbank, P Zool Soc London, 1863, p 466, pl xxxviii, fig 17
Spongilla contecta, Noll, Zool Garten*, 1870, p 173
Spongilla ottavænsis, Dawson, Canad Nat* (new series) viii, p 5 (1878)
Spongilla sibirica, Dybowski, Zool Anz, Jahr i, p 53 (1878)
Spongilla morgiana, Potts, P Ac Philad 1880, p 330
Spongilla lordii, Carter, Ann Nat Hist (5) vii, p 89, pl vi, fig 13 (1881)
Spongilla sibirica, Dybowski, Mém Ac St Pétersb (7) xxx, no x, p 10, fig 12
Spongilla glomerata, Noll, Zool Anz, Jahr ix, p 682 (1886).
Spongilla fragilis, Vejdovsky, P Ac Philad 1887, p 176
Spongilla fragilis, Potts, *ibid* p 197, pl v, fig 2, pl viii, figs 1-4
Spongilla fragilis, Weltner, Arch Naturg lix (i), p 266, pl ix, figs 18-20 (1893)
Spongilla fragilis, *id*, Arch Naturg lxi (i), p 117 (1895)
Spongilla fragilis, *id*, in Semon's Zool Forsch in Austral u d Malay Arch v, part v, p 523
Spongilla fragilis, Annandale, P U S Mus xxxvii, p 402 (1909)
Spongilla fragilis, *id.*, Annot Zool Japon vii, part ii, p 106, pl ii, fig 1 (1909).

Sponge flat, lichenoid, never of great thickness, devoid of branches, dense in texture but very friable, colour brown, green, or whitish, oscula numerous, small, flat, distinctly star shaped

Skeleton with well defined radiating and transverse fibres, which are never strong but form a fairly dense network with a small amount of spongin

Spicules Skeleton-spicules smooth, sharply pointed, moderately stout, as a rule nearly straight No flesh-spicules Gemmule-spicules cylindrical, blunt or abruptly pointed, nearly straight, covered with relatively stout, straight, irregular spines, which are equally distributed all over the spicule

Gemmules bound together in free groups of varying numbers and forming a flat layer at the base of the sponge, each gemmule small in size, surrounded by a thick cellular coat of several layers; with a relatively long and stout foraminal tubule, which projects outwards through the cellular coat at the sides of the group or at the top of the basal layer of gemmules, is usually curved, and is not thickened at the tip, more than one foraminal tubule sometimes present on a single gemmule, gemmule-spicules arranged horizontally or at the base of the cellular coat

The species as a species is easily distinguished from all others, its nearest ally being the N American *S igloviformis* with sparsely spined skeleton-spicules which are very few in number, and gemmule groups in which the foraminal tubules all open downwards

Several varieties of *S fragilis* have been described in Europe and America

TYPE —Potts refers to the type as being in the Academy of Natural Sciences at Philadelphia

GEOGRAPHICAL DISTRIBUTION —All over Europe and N America, also in Siberia, Australia, and S America The species is included in this work in order that its Asiatic local races may be fitly described

9 *a* Subsp **calcuttana***, nov

? *Spongilla decipiens*, Weltner (*partim*), Arch Naturg lxi (1), pp 117, 134 (1895)
Spongilla decipiens, Annandale, Journ As Soc Beng 1906, p 57
Spongilla fragilis, *id*, Rec Ind Mus i, p 390 (1907).

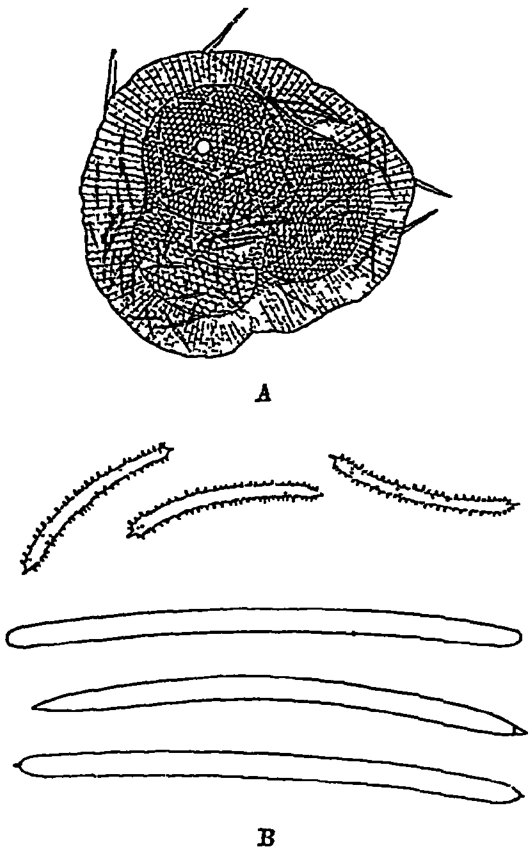


Fig 15 —*Spongilla fragilis* subsp *calcuttana*
A=group of gemmules, ×70, B=spicules, ×240 From type specimen

This local race, which is common in Calcutta, is distinguished from the typical form mainly by the shape of its skeleton-spicules, most of which are abruptly pointed or almost rounded at

the tips, sometimes bearing a minute conical projection at each end The gemmule-spicules, which are usually numerous, are slender The foraminal tubules are usually long and bent, but are sometimes very short and quite straight The colour is usually greyish, occasionally brown.

I have not found this race except in Calcutta, in the ponds of which it grows on bricks or, very commonly, on the stems of bulrushes, often covering a considerable area

TYPE in the Indian Museum

9 *b*. Subsp **decipiens***, *Weber*

Spongilla decipiens, Weber, Zool Ergeb Niederland Ost-Ind i, p 40, pl iv, figs 1-5 (1890)

This (?) local race is distinguished by the fact that the foraminal tubules are invariably short and straight and thickened at the tips, and that gemmule-spicules do not occur on the external surface of the cellular coat of the gemmules

I include Weber's *Spongilla decipiens* in the Indian fauna on the authority of Weltner, who identified specimens from the Museum "tank," Calcutta, as belonging to this form All, however, that I have examined from our "tank" belong to the subspecies *calcuttana*, most of the skeleton-spicules of which are much less sharp than those of *decipiens* By the kindness of Prof Max Weber I have been able to examine a co-type of his species, which is probably a local race peculiar to the Malay Archipelago.

TYPE in the Amsterdam Museum; a co-type in Calcutta

Perhaps the Japanese form, which has spindle-shaped gemmule-spicules with comparatively short and regular spines, should be regarded as a third subspecies, and the Siberian form as a fourth.

10 **Spongilla gemina***, sp nov

Sponge forming small, shallow, slightly dome-shaped patches of a more or less circular or oval outline, minutely hispid on the surface, friable but moderately hard Oscula numerous but minute and inconspicuous, never star-shaped. Dermal membrane adhering closely to the sponge. Colour grey or brown

Skeleton forming a close and regular network at the base of the sponge, becoming rather more diffuse towards the external surface, the radiating and the transverse fibres both well developed, of almost equal diameter Little spongin present

Spicules Skeleton-spicules slender, smooth, sharply pointed No flesh-spicules Gemmule-spicules long, slender, cylindrical blunt or bluntly pointed, somewhat irregularly covered with minute straight spines

Gemmules small, bound together in pairs, as a rule free in the parenchyma but sometimes lightly attached at the base of the sponge Each gemmule flattened on the surface by which it is attached to its twin, covered with a thin coat of polygonal air-spaces which contains two layers of gemmule-spicules crossing one another irregularly in a horizontal plane One or two foraminal

tubules present on the surface opposite the flat one, bending towards the latter, often of considerable length, cylindrical and moderately stout

TYPE in the Indian Museum

This species is closely allied to *S fragilis*, from which it may be distinguished by the curious twinned arrangement of its gemmules It also differs from *S fragilis* in having extremely small and inconspicuous oscula

Locality I only know this sponge from the neighbourhood of Bangalore, where Dr Morris Travers and I found it in October, 1910 growing on stones and on the leaves of branches that dipped into the water at the edge of a large tank

11 **Spongilla crassissima***, *Annandale*

Spongilla crassissima, Annandale, J Asiat Soc Bengal, 1907, p 17, figs 2, 3
Spongilla crassissima, *id*, *ibid* p 88
Spongilla crassissima, *id*, Rec Ind Mus i p 390, pl xiv, fig 4 (1907)

Sponge very hard and strong, nearly black in colour, sometimes with a greenish tinge, forming spherical, spindle-shaped or irregular masses without branches but often several inches in diameter Oscula circular or star-shaped, usually surrounded by radiating furrows, pores normally contained in single cells External membrane closely adherent to the sponge except immediately round the oscula

Skeleton dense, compact and only to be broken by the exercise of considerable force, radiating and transverse fibres not very stout but firmly bound together by spongin (fig 6, p 38), which occasionally extends between them as a delicate film, their network close and almost regular

Spicules Skeleton-spicules smooth, feebly curved, sausage-shaped but by no means short, as a rule bearing at each end a minute conical projection which contains the extremity of the axial filament No flesh-spicules Gemmule-spicules closely resembling those of *S fragilis* subsp. *calcuttana*, but as a rule even more obtuse at the ends

Gemmules as in *S fragilis* subsp *calcuttana*, a basal layer of gemmules rarely formed

11*a* Var **crassior***, *Annandale*

Spongilla crassior, Annandale, Rec Ind Mus i, p 389, pl xiv, fig 3 (1907)

This variety differs from the typical form chiefly in its even stronger skeleton (fig 3, p 33) and its stouter skeleton-spicules, which do not so often possess a terminal projection The sponge is of a brownish colour and forms flat masses of little thickness but of considerable area on sticks and on the stems of water-plants

TYPES —The types of both forms are in the Indian Museum Co-types have been sent to London

GEOGRAPHICAL DISTRIBUTION.—This sponge is only known from Bengal. The variety *crassior* was found at Rajshahi (Rampur Bhulia) on the Ganges, about 150 miles N. of Calcutta, while the typical form is fairly common in the "tanks" of Calcutta and very abundant in the Sur Lake near Puri in Orissa.

BIOLOGY.—*S. crassissima* is usually found near the surface in shallow water. Attached to the roots of the floating water-plant *Pistia stratiotes* it assumes a spherical form, while on sticks or like objects it is spindle-shaped. Sometimes it is found growing on the same stick or reed-stem as *S. carteri*, the two species being in close contact and *S. carteri* always overlapping *S. crassissima*. The dark colour is due to minute masses of blackish pigment in the cells of the parenchyma. The dense structure of the sponge is not favourable to the presence of *incolæ*, but young colonies of the polyzoon *Plumatella fruticosa* are sometimes overgrown by it. Although they may persist for a time by elongating their tubular zoœcia through the substance of the sponge, they do not in these circumstances reach the same development as when they are overgrown by the much softer *S. carteri*.

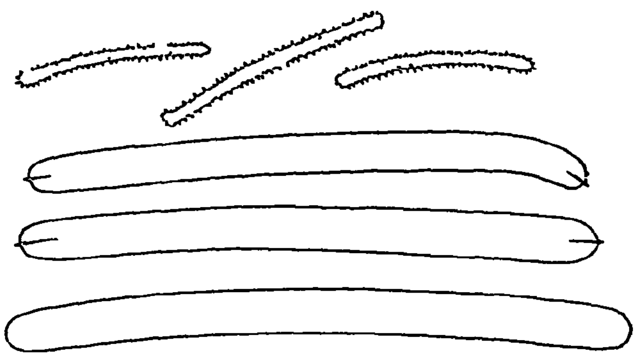


Fig. 16.—Spicules of *Spongilla crassissima* var. *crassior* (from type specimen), × 240.

S. crassissima is found during the "rains" and the cold weather. In Calcutta it attains its maximum size towards the end of the latter season. In spite of its hard and compact skeleton, the sponge does not persist from one cold weather to another.

A curious phenomenon has been noticed in this species, but only in the case of sponges living in an aquarium, viz. the cessation during the heat of the day of the currents produced by its flagella.

Subgenus C STRATOSPONGILLA, *Annandale*

Stratospongilla, Annandale, Zool. Jahrb, Syst xxvii, p 561 (1909)

TYPE, *Spongilla bombayensis*, Carter

Spongillæ in the gemmules of which the pneumatic layer is absent or irregularly developed, its place being sometimes taken by air-spaces between the stout chitinous membranes that cover the gemmule. At least one of these membranes is always present.

The gemmule-spicules lie in the membrane or membranes parallel to the surface of the gemmule, and are often so arranged as to resemble a mosaic The gemmules themselves are usually adherent to the support of the sponge The chitinous membrane or membranes are often in continuity with a membrane that underlies the base of the sponge The skeleton is usually stout, though often almost amorphous, and the skeleton-spicules are sometimes sausage-shaped

Sponges of this subgenus form crusts or sheets on solid submerged objects

Stratospongilla is essentially a tropical subgenus, having its head-quarters in Central Africa and Western India One of its species, however, (*S sumatrana**, Weber) occurs both in Africa and the Malay Archipelago, while another has only been found in S America (*S navicella*, Carter)

Aberrant species occur in China (*S sinensis**, *S coggini**) and the Philippines (*S clementis**) Three species have been found in the Bombay Presidency and Travancore, one of which (*S bombayensis**) extends its range eastwards to Mysore and westwards across the Indian Ocean to Natal

12 Spongilla indica*, *Annandale.*

Spongilla indica, Annandale, Rec Ind Mus ii, p 25, figs 1, 2 (1908)

Sponge forming a very thin layer, of a bright green or pale grey colour, surface smooth, minutely hispid, pores and oscula inconspicuous, the latter approached in some instances by radiating furrows, subdermal cavity small; texture compact, rather hard

Skeleton incoherent, somewhat massive owing to the large number of spicules present Spicules forming triangular meshes and occasionally arranged in vertical lines several spicules broad but without spongin

Spicules Skeleton-spicules straight or nearly straight, slender, cylindrical, amphistrongylous, uniformly covered with minute, sharp spines, flesh-spicules slender, sharply pointed, straight or curved, irregularly covered with relatively long, straight sharp spines, abundant in the dermal membrane, scarce in the substance

of the sponge Gemmule-spicules short, stout, sausage-shaped, covered with minute spines, which are sometimes absent from the extremities

Gemmules spherical, somewhat variable in size, with a single aperture, which is provided with a trumpet-shaped foraminal tubule and is situated at one side of the gemmule in its natural position, the inner chitinous coat devoid of spicules, closely covered by an outer coat composed of a darkly coloured chitinoid substance in which the gemmule-spicules are embedded, lying parallel or almost parallel to the inner coat The outer coat forms a kind of mantle by means of the skirts of which the gemmule is fastened to the support of the sponge This coat is

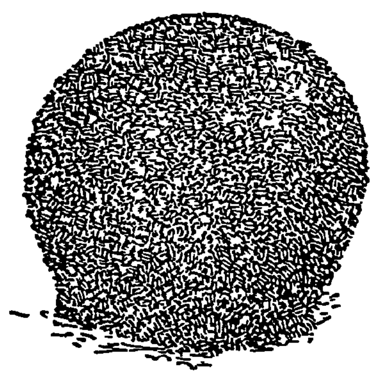


Fig 17 —Gemmule of *Spongilla indica* seen from the side (from type specimen), magnified

pierced by the foraminal tubule. The gemmules are distinct from one another.

Average	length of skeleton-spicules	0 2046 mm
,,	breadth of skeleton-spicules	0 0172 ,,
,,	length of flesh-spicules	0 053 ,,
,,	breadth of flesh-spicules	0 0053 ,,
,,	length of gemmule-spicules	0 044 ,,
,,	breadth of gemmule-spicules	0 0079 ,,

S indica is closely allied to *S sumatrana**, Weber, which has been found both in the Malay Archipelago and in East Africa It may be distinguished by its blunt, almost truncated megascleres and comparatively slender gemmule-spicules

Type in the Indian Museum

Habitat, etc —Growing, together with *S cinerea* and *Corvospongilla lapidosa*, on the stone sides of an artificial conduit in the R Godaveri at Nasik on the eastern side of the Western Ghats in the Bombay Presidency The water was extremely dirty and was used for bathing purposes The sponge was green where

the light fell upon it, grey where it was in the shadow of the bridge under which the conduit ran The only specimens I have seen were taken in November, 1907

13 Spongilla bombayensis* *Carter* (Plate II, fig 2)

Spongilla bombayensis, Carter, Ann Nat Hist (5) x, p 369, pl xvi, figs 1-6 (1882)
Spongilla bombayensis, Annandale, Zool Jahrb, Syst xxvii, p 562, figs B, C (1909)

Sponge hard but friable, forming thin layers or cushions, its surface often irregular but without a trace of branches, its area never very great, oscula inconspicuous, external membrane adhering closely to the sponge, colour brownish or greyish

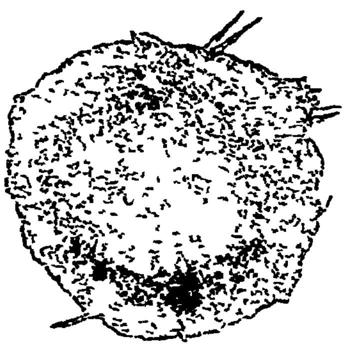


Fig 18 —Gemmule of *Spongilla bombayensis* as seen from above (from type specimen), magnified

Skeleton almost amorphous, very dense, consisting of large numbers of spicules arranged irregularly, radiating fibres occasionally visible in sections, but almost devoid of spongin, a more or less definite reticulation of horizontal spicules lying immediately under the external membrane

Spicules Skeleton-spicules slender, pointed, feebly curved, irregularly roughened or minutely spined all over the surface. Flesh-spicules straight, narrowly rhomboidal in outline, sharply pointed, slender, covered with minute, irregular, straight spines, scanty in the parenchyma, abundant in the external membrane Gemmule-spicules sausage-shaped or bluntly pointed, variable in length but usually rather stout, covered with minute spines, as a rule distinctly curved

Gemmules round or oval, firmly adherent* to the base of the sponge, as a rule rather shallowly dome-shaped, covered by two

* The outer covering by means of which the gemmule is fixed is not formed until the other structures are complete In young sponges, therefore, free gemmules may often be found

thick chitinous membranes, in each of which there is a dense horizontal layer of spicules, no granular or cellular covering, the two chitinous coats separated by an empty space; the aperture or apertures on the side of the gemmule in its natural position, provided with foraminal tubules, which may be either straight or curved, project through the outer chitinous membrane and often bend down towards the base of the gemmule The spicules of the outer layer often more irregular in outline and less blunt than those of the inner layer

This sponge is allied to *S indica*, but is distinguished among other characters by its sharp skeleton-spicules and by the fact that the gemmule is covered by two chitinous membranes instead of one

TYPE in the British Museum, a fragment in the Indian Museum

GEOGRAPHICAL DISTRIBUTION —S and W India and S Africa Carter's type was found in the island of Bombay, my own specimens in Igatpuri Lake in the Western Ghats I have recently (October 1910) found sponges and bare gemmules attached to stones at the end of a tank about 10 miles from Bangalore (Mysore State) in the centre of the Madras Presidency Prof Max Weber obtained specimens in Natal

BIOLOGY —The specimens collected by Prof Weber in Natal and those collected by myself in the Bombay Presidency were both obtained in the month of November. It is therefore very interesting to compare them from a biological point of view In so doing, it must be remembered that while in S. Africa November is near the beginning of summer, in India it is at the beginning of the "cold weather," that is to say, both the coolest and the driest season of the year The lake in which my specimens were obtained had, at the time when they were collected, already sunk some inches below its highest level, leaving bare a gently sloping bank of small stones. Adhering to the lower surface of these stones I found many small patches of *Spongilla bombayensis*, quite dry but complete so far as their harder parts were concerned and with the gemmules fully formed at their base. From the shallow water at the edge of the lake I took many similar stones which still remained submerged It was evident that the sponge had been just as abundant on their lower surface as on that of the stones which were now dry, but only the gemmules remained, sometimes with a few skeleton-spicules adhering to them (Pl II, fig 2) The bulk of the skeleton had fallen away and the parenchyma had wholly perished In a few instances a small sponge, one or two millimetres in diameter, had already been formed among the gemmules, but these young sponges appeared to belong to some other species, possibly *Spongilla indica*, which was also common in the lake

Carter's specimen of *S bombayensis*, which was evidently in much the same condition as those I found still submerged a

month later, was taken in October in a disused quarry It was surrounded by a mass of *S carteri* three inches in diameter, and was attached to a herbaceous annual The point on the edge of the quarry at which this plant grew was not reached by the water until July. It is therefore necessary to assume that the gemmules of *S bombayensis* had been formed between July and October Probably the larva of the sponge had settled down on the plant during the "rains"—which commence in Bombay about the beginning of June—and had grown rapidly The production of gemmules may have been brought about owing to the sponge being choked by the more vigorous growth of *S carteri*, a species which grows to a considerable size in a comparatively short time, while *S bombayensis* apparently never reaches a thickness of more than a few millimetres

The manner in which the gemmules of *S bombayensis* are fastened to the solid support of the sponge must be particularly useful in enabling them to sprout in a convenient environment as soon as the water reaches them The fact that the gemmules remained fixed without support renders it unnecessary for the skeleton to persist as a cage containing them (or at any rate a proportion of them) during the period of rest

Prof Weber's specimens of *S bombayensis* were collected in a river, apparently on stones or rocks, towards the beginning of the S African summer They contain comparatively few gemmules and were evidently in a vigorous condition as regards vegetative growth Unfortunately we know nothing of the seasonal changes which take place in freshwater sponges in S Africa, but the difference between these changes in Europe and in India shows that they are dependent on environment as well as the idiosyncrasy of the species It is very interesting, therefore, to see that the condition of sponges taken in S Africa differs so widely from that of other individuals of the same species taken in India at the same season

In Prof Weber's specimens I have found numerous small tubules of inorganic débris These appear to be the work of Chironomid larvæ, of which there are several specimens loose in the bottle containing the sponges Other tubules of a very similar appearance but with a delicate chitinoid foundation appear to be the remains of a species of *Plumatella* of which they occasionally contain a statoblast

14 Spongilla ultima*, *Annandale* (Plate II, fig 3)

Spongilla ultima, Annandale, Rec Ind Mus v, p 31 (1910)

Sponge hard and strong, forming a thin layer on solid objects, of a pale green colour (dry), the oscula small but rendered conspicuous by the deep radiating furrows that surround them; external surface of the sponge rough but not spiny.

Skeleton forming a compact but somewhat irregular reticulation in which the radiating fibres are not very much more distinct than the transverse ones; a considerable amount of almost colourless spongin present

Spicules Skeleton-spicules smooth, stout, amphioxous, as a rule straight or nearly straight, not infrequently inflated in the middle or otherwise irregular No flesh-spicules Gemmule-spicules variable in size, belonging to practically every type and exhibiting practically every abnormality possible in the genus, the majority being more or less sausage-shaped and having a roughened surface, but others being cruciform, spherical, subspherical, rosette-like, needle-like, bifid or even trifid at one extremity.

Fig 19 —Spicules of *Spongilla ultima* (from type specimen), ×120

Gemmules adherent, spherical, large, each covered by two distinct layers of horizontal spicules, the outer layer intermixed with skeleton-spicules and often containing relatively large siliceous spheres, a large proportion of the spicules being irregular in shape, the spicules of the inner layer much more regular and as a rule sausage-shaped The outer layer is contained in a chitinous membrane which spreads out over the base of the sponge. The foraminal tubules are short and straight.

This sponge is allied to *S bombayensis*, from which it is distinguished not only by the abnormal characters of its gemmule-spicules and the absence of flesh-spicules, but also by the form of its skeleton-spicules and the structure of its skeleton I have examined several specimens dry and in spirit, but *S ultima* is the only Indian freshwater sponge, except *Corvospongilla burmanica*, I have not seen in a fresh condition

TYPES in the Indian Museum, co-types at Trivandrum

HABITAT Discovered by Mr R Shunkara Narayana Pillay, of the Trivandrum Museum, in a tank near Cape Comorin, the southernmost point of the Indian Peninsula

Genus 2 PECTISPONGILLA, *Annandale.*

Pectispongilla, Annandale, Rec. Ind Mus iii, p 103 (1909)

TYPE, *Pectispongilla aurea*. Annandale.

The structure of the sponge resembling that of *Euspongilla* or *Ephydatia*, but the gemmule-spicules bear at either end, at one side only, a double vertical row of spines, so that they appear when viewed in profile like a couple of combs joined together by a smooth bar.

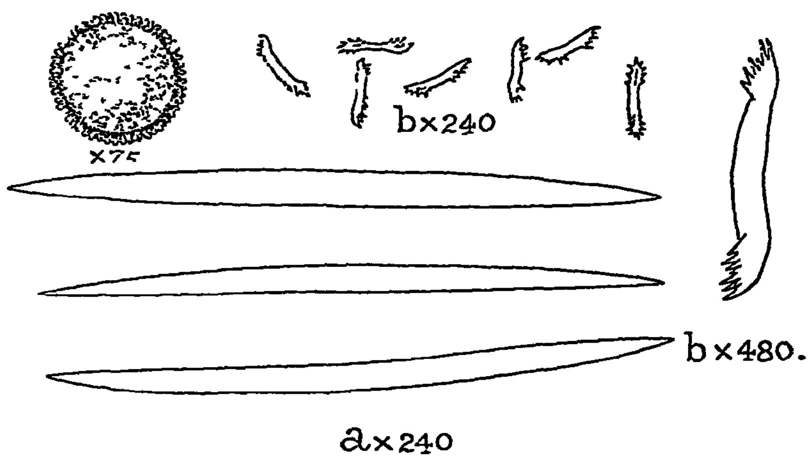


Fig 20 —Gemmule and spicules of *Pectispongilla aurea* (type specimen) *a*, Skeleton-spicules, *b*, gemmule-spicules, *b'*, a single gemmule-spicule more highly magnified

GEOGRAPHICAL DISTRIBUTION —The genus is monotypic and is only known from Travancore and Cochin in the south-west of the Indian Peninsula

15. Pectispongilla aurea*, *Annandale*

Pectispongilla aurea Annandale, *op cit*, p 103, pl xii, fig 2

Sponge forming minute, soft, cushion-like masses of a deep golden colour (dull yellow in spirit), the surface smooth, minutely hispid One relatively large depressed osculum usually present in each sponge, pores inconspicuous, dermal membrane in close contact with the parenchyma

Skeleton consisting of slender and feebly coherent radiating fibres as a rule two or three spicules thick, with single spicules or ill-defined transverse fibres running horizontally Towards the

external surface transverse spicules are numerous, but they do not form any very regular structure

Spicules Skeleton-spicules smooth, sharply pointed, straight or nearly so Gemmule-spicules minute, with the stem smooth and cylindrical, relatively stout and much longer than the comb at either end, the two combs equal, with a number of minute, irregularly scattered spines between the two outer rows of stouter ones No free microscleres

Gemmules minute, spherical, with a single aperture, which is provided with a very short foraminal tubule, the granular coat well developed, the spicules arranged in a slanting position, but more nearly vertically than horizontally, with the combs pointing in all directions, no external chitinous membrane

Length of skeleton-spicule	0 2859 mm
Greatest diameter of skeleton-spicule	0 014 ,,
Length of gemmule-spicule .	0 032–0 036 mm.
Length of comb of gemmule-spicule	0 008 mm
Greatest diameter of shaft of gemmule-spicule .	0 004 ,,
Diameter of gemmule ..	0 204–0 221 mm.

The gemmule-spicules first appear as minute, smooth, needle-like bodies, which later become roughened on one side at either end and so finally assume the mature form. There are no bubble-cells in the parenchyma

15 *a* Var subspinosa*, nov.

This variety differs from the typical form in having its skeleton spicules covered with minute irregular spines or conical projections

Types of both the typical form and the variety in the Indian Museum, co-types of the typical form in the Trivandrum Museum

Geographical Distribution —The same as that of the genus

Localities —Tenmalai, at the base of the western slopes of the W Ghats in Travancore (typical form) (*Annandale*); Ernakulam and Trichur in Cochin (var *subspinosa*) (*G Mathai*)

Biology —My specimens, which were taken in November, were growing on the roots of trees at the edge of an artificial pool by the roadside They were in rather dense shade, but their brilliant golden colour made them conspicuous objects in spite of their small size Mr Mathai's specimens from Cochin were attached to water-weeds and to the husk of a cocoanut that had fallen or been thrown into the water

Genus 3 EPHYDATIA, *Lamouroux*.

Ephydatia, Lamouroux, Hist. des Polyp corall flex* p 6 (*fide* Weltner) (1816)
Ephydatia, J E Gray, P Zool Soc London, 1867, p 550
Trachyspongilla, Dybowsky (*partim*), Zool Anz i, p 53 (1874)
Meyenia, Carter (*partim*), Ann Nat Hist (5) vii, p 90 (1881)
Carterella, Potts & Mills (*partim*), P Ac Philad 1881, p 150
Ephydatia, Vejdovsky, Abh Bohm Ges xii, p 23 (1883)
Meyenia, Potts (*partim*), *ibid* 1887, p 210
Carterella, *id* (*partim*), *ibid* 1887, p 260.
Ephydatia, Weltner (*partim*), Arch Naturg lxi (i), p 121 (1895)
Ephydatia, Annandale, P U S Mus xxxvii, p 404 (1909)

TYPE, (?) *Spongilla fluviatilis*, auctorum
This genus is separated from *Spongilla* by the structure of the gemmule-spicules, which bear at either end a transverse disk with serrated or deeply notched edges, or at any rate with edges that are distinctly undulated The disks are equal and similar True flesh-spicules are usually absent, but more or less perfect birotulates exactly similar to those associated with the gemmules are often found free in the parenchyma The skeleton is never very stout and the skeleton-spicules are usually slender.

As has been already stated, some authors consider *Ephydatia* as the type-genus of a subfamily distinguished from the subfamily of which *Spongilla* is the type-genus by having rotulate gemmule-spicules The transition between the two genera, however, is a very easy one Many species of the subgenus *Euspongilla*, the typical subgenus of *Spongilla* (including *S. lacustris*, the type-species of the genus), have the spines at the ends of the gemmule-spicules arranged in such a way as to suggest rudimentary rotules, while in the typical form of *S crateriformis* this formation is so distinct that the species has hitherto been placed in the genus *Ephydatia* (*Meyenia*), although in some sponges that agree otherwise with the typical form of the species the gemmule-spicules are certainly not rotulate and in none do these spicules bear definite disks

GEOGRAPHICAL DISTRIBUTION —*Ephydatia*, except *Spongilla*, is the most generally distributed genus of the Spongillidæ, but in most countries it is not prolific in species In Japan, however, it appears to predominate over *Spongilla* Only one species is known from India, but another (*E blembingia**, Evans) has been described from the Malay Peninsula, while Weber found both the Indian species and a third (*E bogorensis**) in the Malay Archipelago

16. Ephydatia meyeni* (*Carter*)

Spongilla meyeni, Carter, J Bomb Asiat Soc iii, p 33, pl i, fig 1, & Ann Nat Hist (2) iv, p 84, pl iii, fig 1 (1849)
Spongilla meyeni, Bowerbank, P Zool Soc London, 1863, p 448, pl xxxviii, fig 4
Spongilla meyeni, Carter, Ann Nat Hist (5) vii, p 93 (1881)

Ephydatia fluviatilis, Weber, Zool Ergeb. Niederland Ost-Ind i pp 32, 46 (1890)
Ephydatia mulleri, Weltner (*partim*), Arch Naturg lxi (i), p 125 (1895)
Ephydatia robusta, Annandale, J Asiat Soc Bengal, 1907, p 24, fig 7
Ephydatia mulleri subsp *meyeni*, *id*, Rec Ind Mus ii, p 306 (1908)

Sponge hard and firm but easily torn, usually of a clear white, sometimes tinged with green, forming irregular sheets or masses never of great thickness, without branches but often with stout subquadrate projections, the summits of which are marked with radiating grooves, the whole surface often irregularly nodulose and deeply pitted, the oscula inconspicuous, the membrane adhering closely to the parenchyma *The parenchyma contains numerous bubble-cells* (see p 31, fig 2)

Skeleton dense but by no means regular, the radiating fibres distinct and containing a considerable amount of spongin, at any rate in the outer part of the sponge, transverse fibres hardly distinguishable, single spicules and irregular bundles of spicules taking their place

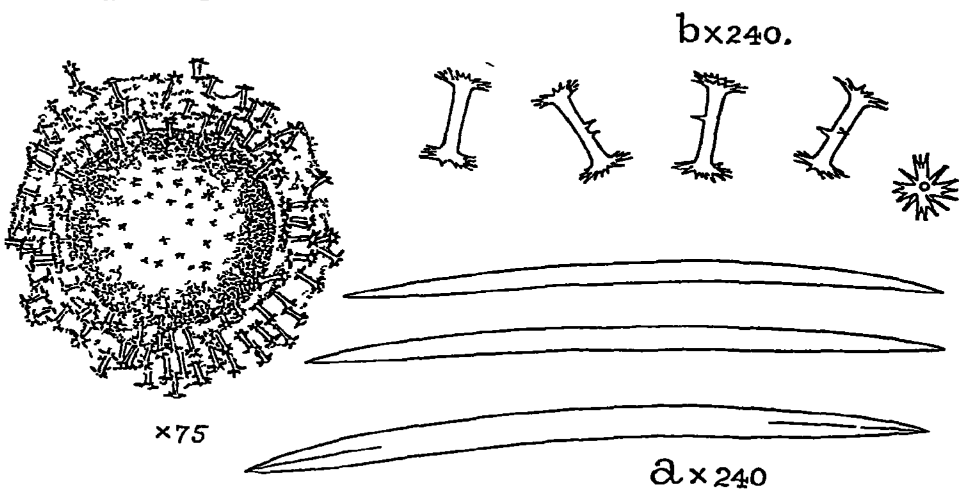


Fig 21 —Gemmule and spicules of *Ephydatia meyeni* (from Calcutta) *a*, Skeleton-spicules, *b*, gemmule-spicules

Spicules Skeleton-spicules entirely smooth, moderately stout, feebly curved, sharply pointed No flesh-spicules Gemmule-spicules with the shaft as a rule moderately stout, much longer than the diameter of one disk, smooth or with a few stout, straight horizontal spines which are frequently bifid or trifid, the disks flat, of considerable size, with their margins cleanly and deeply divided into a comparatively small number of deep, slender, triangular processes of different sizes, the shaft extending not at all or very little beyond the disks

Gemmules spherical, usually numerous and of rather large size, each covered by a thick layer of minute air-spaces, among which the gemmule-spicules are arranged vertically, often in two or even

three concentric series, a single short foraminal tubule; the pneumatic coat confined externally by a delicate membrane, with small funnel-shaped pits over the spicules of the outer series

I think that the gemmules found by me in Bhim Tal and assigned to Potts's *Meyenia robusta* belong to this species, but some of the spicules are barely as long as the diameter of the disks In any case Potts's description is so short that the status of his species is doubtful. His specimens were from N America

E meyeni is closely related to the two commonest Holarctic species of the genus, *E fluviatilis* and *E mulleri*, which have been confused by several authors including Potts From *E fluviatilis* it is distinguished by the possession of bubble-cells in the parenchyma, and from *E. mulleri* by its invariably smooth skeleton-spicules and the relatively long shafts of its gemmule-spicules The latter character is a marked feature of the specimens from the Malay Archipelago assigned by Prof Max Weber to *E fluviatilis*, I am indebted to his kindness for an opportunity of examining some of them

TYPE in the British Museum; a fragment in the Indian Museum

GEOGRAPHICAL DISTRIBUTION.—India and Sumatra *Localities* —BENGAL, Calcutta and neighbourhood (*Annandale*), MADRAS PRESIDENCY, Cape Comorin, Travancore (*Trivandrum Mus*) BOMBAY PRESIDENCY, Island of Bombay (*Carter*) · HIMALAYAS, Bhim Tal, Kumaon (alt 4,500 feet) (*Annandale*)

BIOLOGY —My experience agrees with Carter's, that this species is never found on floating objects but always on stones or brickwork. It grows in the Calcutta "tanks" on artificial stonework at the edge of the water, together with *Spongilla carteri*, *S alba*, *S fragilis* subsp *calcuttana*, and *Trochospongilla latouchiana* It flourishes during the cold weather and often occupies the same position in succeeding years In this event the sponge usually consists of a dead base, which is of a dark brownish colour and contains no cells, and a living upper layer of a whitish colour.

The larva of *Sisyra indica* is sometimes found in the canals, but the close texture of the sponge does not encourage the visits of other *incolæ*.

Genus 4 DOSILIA, *Gray*.

Dosilia, J E Gray, P Zool Soc London, 1867, p 550

TYPE, *Spongilla plumosa*, Carter

This genus is distinguished from *Ephydatia* by the nature of the free microscleres, the microscleres of the gemmule being similar in the two genera The free microscleres consist as a rule of several or many shafts meeting together in several or many planes at a common centre, which is usually nodular The free ends of these shafts often possess rudimentary rotulæ Occasionally a free microsclere may be found that is a true monaxon and sometimes such spicules are more or less distinctly

birotulate The skeleton is also characteristic It consists mainly of radiating fibres which bifurcate frequently in such a way that a bush-like structure is produced Transverse fibres are very feebly developed and are invisible to the naked eye Owing to the structure of the skeleton the sponge has a feathery appearance

Gray originally applied the name *Dosilia* to this species and to "*Spongilla*" *baileyi*, Bowerbank It is doubtful how far his generic description applies to the latter, which I have not seen, but although the position of "*Spongilla*" *baileyi* need not be discussed here, I may say that I do not regard it as a congener of *Dosilia plumosa*, the free microscleres of which are of a nature rare but not unique in the family. With *Dosilia plumosa* we must, in any case, associate in one genus the two forms that have been described as varieties, viz., *palmeri**, Potts from Texas and Mexico, and *browni**, Kirkpatrick from the White Nile By the kindness of the authorities of the Smithsonian Institution and the British Museum I have been able to examine specimens of all three forms, in each case identified by the author of the name and I am inclined to regard them as three very closely allied but distinct species Species with free microscleres similar to those of these three forms but with heterogeneous or tubelliform gemmule-spicules will probably need the creation of a new genus or new genera for their reception

GEOGRAPHICAL DISTRIBUTION —The typical species occurs in Bombay and Madras, *D palmeri* has probably an extensive range in the drier parts of Mexico and the neighbouring States, while *D browni* has only been found on the banks of the White Nile above Khartoum, in Tropical Africa

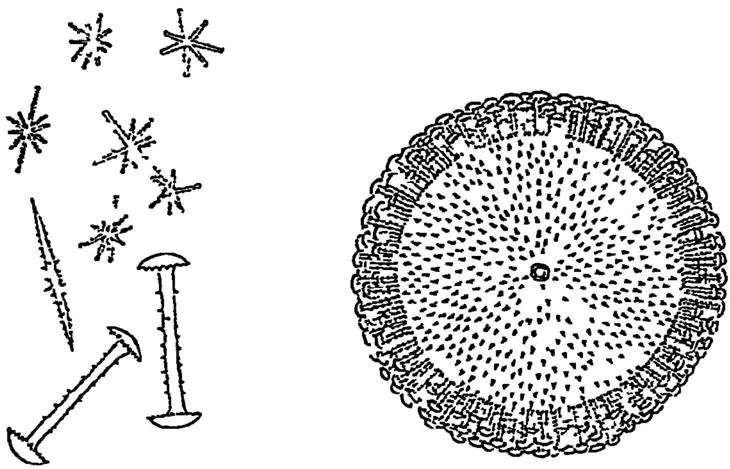
17. **Dosilia plumosa*** (*Carter*).

Spongilla plumosa, Carter, J. Bomb Asiat Soc iii, p 34, pl i, fig 2, & Ann Nat Hist (2) iv, p 85, pl iii, fig 2 (1849)
Spongilla plumosa, Bowerbank, P Zool Soc London, 1863, p 449, pl xxxviii, fig 5
Dosilia plumosa, J E Gray, *ibid* 1867, p 551
Meyenia plumosa, Carter, Ann Nat Hist (5) vii, p 94, pl v, fig. 6 (1881).
Meyenia plumosa, Potts, P Ac Philad 1887, p 233
Ephydatia plumosa, Weltner, Arch Naturg lxi (i), p 126 (1895)
Ephydatia plumosa, Petr, Rozp Ceske Ak Praze, Trída ii, pl ii, figs 29, 30 (text in Czech) (1899)

Sponge forming soft irregular masses which are sometimes as much as 14 cm. in diameter, of a pale brown or brilliant green colour, no branches developed but the surface covered with irregular projections usually of a lobe-like nature

Skeleton delicate, with the branches diverging widely, exhibiting the characteristic structure of the genus in a marked degree, containing a considerable amount of chitin, which renders it resistant in spite of its delicacy

Spicules Skeleton-spicules smooth, sharply pointed, nearly straight, moderately slender, about twenty times as long as their greatest transverse diameter Flesh-spicules occasionally amphioxous or birotulate and with a single shaft, more frequently consisting of many shafts meeting in a distinct central nodule, which is itself smooth; the shafts irregularly spiny, usually more or less



A B

Fig 22 —*Doslia plumosa*

A = microscleres, × 240, B = gemmule as seen in optical section from below, × 75 (From Rambha)

nodular at the tip, which often bears a distinct circle of recurved spines that give it a rotulate appearance Gemmule-spicules with long, slender, straight shafts, which bear short, slender, straight, horizontal spines sparsely and irregularly scattered over their surface; the rotulæ distinctly convex when seen in profile; their edge irregularly and by no means deeply notched, the shafts not extending beyond their surface but clearly seen from above as circular umbones

Gemmules Somewhat depressed, covered with a thick granular pneumatic coat, in which the spicules stand erect, the single aperture depressed Each gemmule surrounded more or less distinctly by a circle or several circles of flesh-spicules

TYPE in the British Museum, some fragments in the Indian Museum

GEOGRAPHICAL DISTRIBUTION —Bombay and Madras Carter's specimens were taken in the island of Bombay, mine at Rambha in the north-east of the Madras Presidency I have been unable to discover this species in the neighbourhood of Calcutta, but it is apparently rare wherever it occurs

BIOLOGY —Carter writes as regards this species —"This is the coarsest and most resistant of all the species As yet I have only found three or four specimens of it, and these only in two tanks

I have never seen it fixed on any solid body, but always floating on the surface of the water, about a month after the first heavy rains of the S.W. monsoon have fallen. Having made its appearance in that position, and having remained there for upwards of a month, it then sinks to the bottom. That it grows like the rest, adherent to the sides of the tank, must be inferred from the first specimen which I found (which exceeds two feet in circumference) having had a free and a fixed surface, the latter coloured by the red gravel on which it had grown. I have noticed it growing, for two successive years in the month of July, on the surface of the water of one of the two tanks in which I have found it, and would account for its temporary appearance in that position, in the following way, viz., that soon after the first rains have fallen, and the tanks have become filled, all the sponges in them appear to undergo a partial state of putrescency, during which gas is generated in them, and accumulates in globules in their structure, through which it must burst, or tear them from their attachments and force them to the surface of the water. Since then the coarse structure of *plumosa* would appear to offer greater resistance to the escape of this air, than that of any of the other species, it is probable that this is the reason of my having hitherto only found it in the position mentioned."

It seems to me more probable that the sponges are actually broken away from their supports by the violence of the rain and retain air mechanically in their cavities. The only specimens of *D. plumosa* that I have seen alive were attached very loosely to their support. In writing of the "coarse structure" of this species, Carter evidently alludes to the wide interspaces between the component branches of the skeleton.

My specimens were attached to the stem of a water-lily growing in a pool of slightly brackish water and were of a brilliant green colour. I mistook them at first for specimens of *S. lacustris* subsp. *reticulata* in which the branches had not developed normally. They were taken in March and were full of gemmules. The pool in which they were growing had already begun to dry up.

Genus 5. TROCHOSPONGILLA, *Vejdovsky*.

Trochospongilla, Vejdovsky, Abh. K. Böhm. Ges. Wiss. xii, p. 31 (1883).
Trochospongilla, Wierzejski, Arch. Slaves de Biologie, i, p. 44 (1886).
Trochospongilla, Vejdovsky, P. Ac. Philad. 1887, p. 176.
Meyenia, Potts (*partim*), *ibid.* p. 210.
Tubella, *id.* (*partim*), *ibid.*, p. 248.
Meyenia, Carter (*partim*), Ann. Nat. Hist. (5) vii, p. 90 (1881).
Trochospongilla, Weltner, in Zacharias's Tier- und Pflanzenwelt, i, p. 215 (1891).
Trochospongilla, *id.*, Arch. Naturg. lxi (i), p. 120 (1895).
Tubella, *id.* (*partim*), *ibid.* p. 128.

TYPE, *Spongilla erinaceus*, Ehrenberg.

The characteristic feature of this genus is that the rotulæ of the gemmule-spicules, which are homogeneous, have smooth instead of serrated edges. Their stem is always short and they are usually embedded in a granular pneumatic coat. The sponge is small in most of the species as yet known; in some species microscleres without rotulæ are associated with the gemmules.

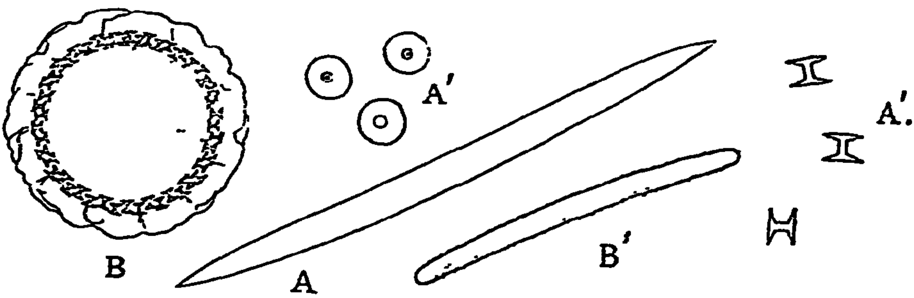


Fig 23.—A=skeleton-spicule of *Trochospongilla latouchiana*; A'=gemmule-spicule of the same species; B=gemmule of *T. phillottiana* as seen in optical section from above; B'=skeleton-spicule of same species. A, A', B' × 240; B × 75. All specimens from Calcutta.

I think it best to include in this genus, as the original diagnosis would suggest, all those species in which all the gemmule-spicules are definitely birotulate and have smooth edges to their disks, confining the name *Tubella* to those in which the upper rotula is reduced to a mere knob. Even in those species in which the two disks are normally equal, individual spicules may be found in which the equality is only approximate, while, on the other hand, it is by no means uncommon for individual spicules in such species as "*Tubella*" *pennsylvanica*, which is here included in *Trochospongilla*, to have the two disks nearly equal, although normally the upper one is much smaller than the lower. There is very rarely any difficulty, however, in seeing at a glance whether the edge of the disk is smooth or serrated, the only species in which this difficulty would arise being, so far as I am aware, the Australian *Ephydatia capewelli** (Haswell), the disks of which are undulated and nodulose rather than serrated.

Geographical Distribution.—The genus includes so large a proportion of small, inconspicuous species that its distribution is probably known but imperfectly. It would seem to have its headquarters in N. America but also occurs in Europe and Asia. In India three species have been found, one of which (*T. pennsylvanica*) has an extraordinarily wide and apparently discontinuous range, being common in N. America, and having been found in the west of Ireland, the Inner Hebrides, and near the west coast of S. India. The other two Indian species are apparently of not uncommon occurrence in eastern India and Burma.

Key to the Indian Species of Trochospongilla.

I Rotules of the gemmule-spicules equal or nearly so	
A Skeleton-spicules smooth, usually pointed	*latouchiana*, p 115
B Skeleton-spicules spiny, blunt .	*phillottiana*, p 117
II Upper rotule of the gemmule-spicules distinctly smaller than the lower	
Skeleton-spicules spiny, pointed	*pennsylvanica*, p 118

18 Trochospongilla latouchiana*, *Annandale.*

Trochospongilla latouchiana, Annandale, J. Asiat Soc Bengal, 1907, p 21, fig 5
Trochospongilla latouchiana, *id*, Rec Ind. Mus ii, p 157 (1908)
Trochospongilla leidyi, *id* (*nec* Bowerbank), *ibid* iii, p 103 (1909)

Sponge forming cushion-shaped masses rarely more than a few centimetres in diameter or thickness and of a brown or yellow

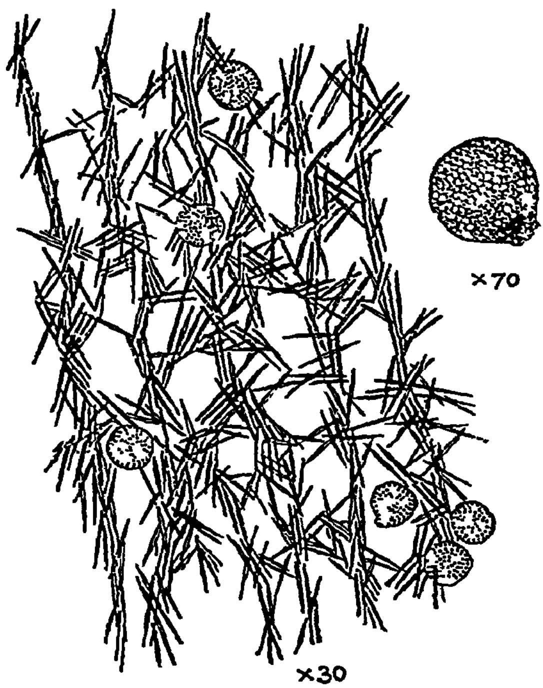


Fig 24 —*Trochospongilla latouchiana*

Vertical section of part of skeleton with gemmules *in situ*, × 30, also a single gemmule, × 70 (From Calcutta)

colour, hard but rather brittle, surface evenly rounded, minutely hispid, oscula inconspicuous, small, circular, depressed, very few in number, external membrane adhering closely to the parenchyma,

a chitinous membrane at the base of the sponge Larger sponges divided into several layers by similar membranes

Skeleton dense, forming a close reticulation; radiating fibres slender but quite distinct, running up right through the sponge, crossed at frequent intervals by single spicules or groups of spicules

Spicules Skeleton-spicules smooth, about twenty times as long as the greatest transverse diameter, as a rule sharply pointed, smooth amphistrongyli, which are often inflated in the middle, sometimes mixed with them but never in large numbers No flesh-spicules Gemmule-spicules with the rotulæ circular or slightly asymmetrical, flat or nearly flat, marked with a distinct double circle as seen from above. sometimes not quite equal, the shaft not projecting beyond them, the diameter of the rotule $4\frac{1}{2}$ to 5 times that of the shaft, which is about $2\frac{2}{3}$ times as long as broad

Gemmules small (0 2×0 18 mm), as a rule very numerous and scattered throughout the sponge, flask-shaped, clothed when mature with a thin microcell coat in which the birotulates are arranged with overlapping rotulæ, their outer rotulæ level with the surface, foraminal aperture circular, situated on an eminence.

Average Measurements

Diameter of gemmule	0·2×0 18	mm
Length of skeleton-spicule	0 28	,,
Length of birotulate-spicule	0 175	,,
Diameter of rotula	0 02	,,

T latouchiana is closely related to *T leidyi* (Bowerbank) from N. America, but is distinguished by its much more slender skeleton-spicules, by the fact that the gemmules are not enclosed in cages of megascleres or confined to the base of the sponge, and by differences in the structure of the skeleton

TYPE in the Indian Museum.

GEOGRAPHICAL DISTRIBUTION.—Lower Bengal and Lower Burma *Localities*—BENGAL, Calcutta and neighbourhood (*Annandale*) BURMA, Kawkareik, Amherst district, Tenasserim (*Annandale*)

BIOLOGY—This species, which is common in the Museum tank, Calcutta, is apparently one of those that can grow at any time of year, provided that it is well covered with water Like *T leidyi* it is capable of producing fresh layers of living sponge on the top of old ones, from which they are separated by a chitinous membrane. These layers are not, however, necessarily produced in different seasons, for it is often clear from the nature of the object to which the sponge is attached that they must all have been produced in a short space of time What appears to happen in most cases is this:—A young sponge grows on a brick, the stem of a reed or some other object at or near the edge

of a pond, the water in which commences to dry up As the sponge becomes desiccated its cells perish Its gemmules are, however, retained in the close-meshed skeleton, which persists without change of form A heavy shower of rain then falls, and the water rises again over the dried sponge The gemmules germinate immediately and their contents spread out over the old skeleton, secrete a chitinous membrane and begin to build up a new sponge The process may be repeated several times at the change of the seasons or even during the hot weather, or after a "break in the rains" If, however, the dried sponge remains exposed to wind and rain for more than a few months, it begins to disintegrate and its gemmules are carried away to other places. Owing to their thin pneumatic coat and relatively heavy spicules they are not very buoyant Even in the most favourable circumstances the sponge of *T. latouchiana* never forms sheets of great area In spite of its rapid growth it is frequently overgrown by *Spongilla carteri*

19 **Trochospongilla phillottiana***, *Annandale.*

Trochospongilla phillottiana, Annandale, J Asiat. Soc Bengal, 1907, p 22, fig 6
Trochospongilla phillottiana, *id*, Rec Ind Mus i, p 269 (1907)
Trochospongilla phillottiana, *id*, *ibid* ii, p 157 (1908)

Sponge hard but friable, forming sheets or patches often of great extent but never more than about 5 mm. thick, the surface minutely hispid, flat, colour pale yellow, the golden-yellow gemmules shining through the sponge in a very conspicuous manner, oscula inconspicuous, external membrane adherent, no basal chitinous membrane

Skeleton dense but by no means strong, the reticulation close but produced mainly by single spicules, which form triangular meshes, radiating fibres never very distinct, only persisting for a short distance in a vertical direction; each gemmule enclosed in an open, irregular cage of skeleton-spicules.

Spicules. Skeleton-spicules short, slender, blunt, more or less regularly and strongly spiny, straight or feebly curved. No flesh-spicules Gemmule-spicules with the rotulæ circular, very wide as compared with the shaft, concave on the surface, with the shaft projecting as an umbo on the surface, the lower rotula often a little large than the upper

Gemmules numerous, situated at the base of the sponge in irregular, one-layered patches, small (0 32×0 264 mm), of a brilliant golden colour, distinctly wider than high, with a single aperture situated on an eminence on the apex, each clothed (when mature) with a pneumatic coat that contains relatively large but irregular air-spaces among which the spicules stand with the rotulæ overlapping alternately, a funnel-shaped pit in the coat descending from the surface to the upper rotula of each of them, the surface of the gemmule covered with irregular projections

Diameter of gemmule	0·32 × 0 264 mm.
Length of skeleton-spicule .	0 177 „
Length of gemmule-spicule	0 015 „
Diameter of rotule .	. 0 022 „

This species appears to be related to *T. pennsylvanica*, from which it differs mainly in the form of its gemmule-spicules and the structure of its gemmule. My original description was based on specimens in which the gemmule-spicules were not quite mature

TYPE in the Indian Museum

GEOGRAPHICAL DISTRIBUTION.—Lower Bengal and Lower Burma *Localities*:—BENGAL, Calcutta (*Annandale*) BURMA, jungle pool near Kawkareik, Amherst district, Tenasserim (*Annandale*).

BIOLOGY —This species covers a brick wall at the edge of the Museum tank in Calcutta every year during the "rains" In the cold weather the wall is left dry, but it is usually submerged to a depth of several feet before the middle of July. It is then rapidly covered by a thin layer of the sponge, which dies down as soon as the water begins to sink when the "rains" are over. For some months the gemmules adhere to the wall on account of the cage of spicules in which each of them is enclosed, but long before the water rises again the cages disintegrate and the gemmules are set free Many of them fall or are carried by the wind into the water, on the surface of which, owing to their thick pneumatic coat, they float buoyantly Others are lodged in cavities in the wall. On the water the force of gravity attracts them to one another and to the edge of the pond, and as the water rises they are carried against the wall and germinate In thick jungle at the base of the Dawna Hills near Kawkareik † in the interior of Tenasserim, I found the leaves of shrubs which grew round a small pool, covered with little dry patches of the sponge, which had evidently grown upon them when the bushes were submerged This was in March, during an unusually severe drought.

20 Trochospongilla pennsylvanica * (*Potts*).

Tubella pennsylvanica, Potts, P Ac Philad 1882, p 14
Tubella pennsylvanica, *id*, *ibid* 1887, p 251, pl vi, fig 2, pl xii, figs 1-3
Tubella pennsylvanica, Mackay, Trans Roy Soc Canada, 1889, Sec iv, p 95
Tubella pennsylvanica, Hanitsch, Nature, li, p 511 (1895)
Tubella pennsylvanica, Weltner, Arch Naturg lxi (i), p 128 (1895)
Tubella pennsylvanica, Hanitsch, Irish Natural iv, p 129 (1895)
Tubella pennsylvanica, Annandale, J Linn Soc, Zool, xxx, p 248 (1908).
Tubella pennsylvanica, *id*, Rec Ind Mus iii, p 102 (1909)
Tubella pennsylvania, *id*, P U S Mus xxxvii, p 403, fig 2 (1909)

† This locality is often referred to in zoological literature as Kawkare*et* or Kawkari*t*, or even Kokari*t*.

Sponge soft, fragile, forming small cushion-shaped masses, grey or green, oscula few in number, often raised on sloping eminences surrounded by radiating furrows below the external membrane, external membrane adhering to the parenchyma

Skeleton close, almost structureless "Surface of mature specimens often found covered with parallel skeleton spicules, not yet arranged to form cell-like interspaces" (*Potts*)

Spicules Skeleton-spicules slender, cylindrical, almost straight, sharp or blunt, minutely, uniformly or almost uniformly spined, spines sometimes absent at the tips. No flesh-spicules. Gemmule-spicules with the lower rotula invariably larger than the upper; both rotulæ flat or somewhat sinuous in profile, usually circular but sometimes asymmetrical or subquadrate in outline, varying considerably in size

Gemmules small, numerous or altogether absent, covered with a granular pneumatic coat of variable thickness, the rotulæ of the gemmule-spicules overlapping and sometimes projecting out of the granular coat

The measurements of the spicules and gemmules of an Indian specimen and of one from Lehigh Gap, Pennsylvania, are given for comparison:—

	Travancore	Pennsylvania
Length of skeleton-spicules	0 189–0 242 mm (average 0 205 mm)	0 16–0 21 mm (average 0 195 mm)
Breadth " "	0 0084- 0 0155 mm	0 0084 mm
Length of birotulate	0 0126 "	0 0099 "
Diameter of upper rotula	0 0084 "	0 0084 "
" lower "	0 0169 "	0 0168 "
" gemmule	0 243–0 348 mm	0 174–0 435 mm

The spicules of the Travancore specimen are, therefore, a trifle larger than those of the American one, but the proportions are closely similar

The difference between the gemmule-spicules of this species and those of such a form as *T. phillottiana* is merely one of degree and can hardly be regarded as a sufficient justification for placing the two species in different genera If, as I have proposed, we confine the generic name *Tubella* to those species in which the gemmule-spicules are really like "little trumpets," the arrangement is a much more natural one, for these species have much in common apart from the gemmule-spicules *T. pennsylvanica* does not appear to be very closely related to any other known species except *T phillottiana*.

TYPE in the U.S National Museum, from which specimens that appear to be co-types have been sent to the Indian Museum

GEOGRAPHICAL DISTRIBUTION —Very wide and apparently discontinuous:—N America (widely distributed), Ireland (*Hanitsch*), Hebrides of Scotland (*Annandale*), Travancore, S India (*Annandale*) The only Indian locality whence I have obtained specimens is Shasthancottah Lake near Quilon in Travancore

BIOLOGY.—In Shasthaucottah Lake *T pennsylvanica* is found on the roots of water-plants that are matted together to form floating islands It appears to avoid light and can only be obtained from roots that have been pulled out from under the islands In Scotland I found it on the lower surface of stones near the edge of Loch Baa, Isle of Mull. In such circumstances the sponge is of a greyish colour, but specimens of the variety *minima* taken by Potts on rocks and boulders in Bear Lake, Pennsylvania, were of a bright green

Sponges taken in Travancore in November were full of gemmules, in my Scottish specimens (taken in October) I can find no traces of these bodies, but embryos are numerous

Genus 6 TUBELLA, *Carter.*

Tubella, Carter, Ann Nat Hist (5) vii, p 96 (1881)
Tubella, Potts (*partim*), P Ac Philad 1887, p 248
Tubella, Weltner (*partim*), Arch Naturg lxi (i), p 128 (1895)

TYPE, *Spongilla paulula*, Bowerbank

This genus is distinguished from *Ephydatia* and *Trochospongilla* by the fact that the two ends of the gemmule-spicules are unlike *not only in size but also in form* It sometimes happens that this unlikeness is not so marked in some spicules as in others, but in some if not in all the upper end of the shaft (that is to say the end furthest removed from the inner coat of the gemmule in the natural position) is reduced to a rounded knob, while the lower end expands into a flat transverse disk with a smooth or denticulated edge The spicule thus resembles a little trumpet resting on its mouth The shaft of the spicule is generally slender and of considerable length The skeleton of the sponge is as a rule distinctly reticulate and often hard, the skeleton-spicules are either slender or stout and sometimes change considerably in proportions and outline as they approach the gemmules

GEOGRAPHICAL DISTRIBUTION.—The genus is widely distributed in the tropics of both Hemispheres, its headquarters apparently being in S America, but it is nowhere rich in species Only two are known from the Oriental Region, namely *T vesparium* * from Borneo, and *T vesparioides* * from Burma

21 Tubella vesparioides *, *Annandale.* (Plate II, fig. 4)

Tubella vesparioides, Annandale, Rec Ind Mus ii, p 157 (1908)

Sponge forming rather thick sheets of considerable size, hard but brittle, almost black in colour, oscula inconspicuous, external membrane supported on a reticulate horizontal skeleton

Skeleton The surface covered with a network of stout spicule-fibres, the interstices of which are more or less deeply sunk, with sharp fibres projecting vertically upwards at the nodes, the whole mass pervaded by a similar network, which is composed of a considerable number of spicules lying parallel to one another,

overlapping at the ends and bound together by a profuse secretion of spongin

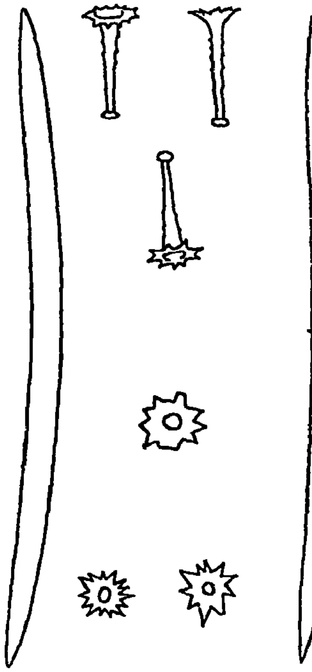


Fig 25 —Spicules of *Tubella vesparioides* (from type specimen) ×240

Spicules Skeleton-spicules slender, smooth, amphioxous, bent in a wide arc or, not infrequently, at an angle No true flesh-spicules. Gemmule-spicules terminating above in a rounded, knob-like structure and below in a relatively broad, flat rotula, which is very deeply and irregularly indented round the edge when mature, the spicules at an earlier stage of development having the form of a sharp pin with a round head, shaft of adult spicules projecting slightly below the rotula, long, slender, generally armed with a few stout conical spines, which stand out at right angles to it

Gemmules numerous throughout the sponge, spherical, provided with a short, straight foraminal tubule, surrounded by one row of spicules, which are embedded in a rather thin granular coat

Average length of skeleton-spicule	0 316 mm
" breadth of skeleton-spicule	0 0135 "
" length of gemmule-spicule	0 046 "
" diameter of rotula	0 0162 "
" " gemmule	0 446 "

This sponge is closely related to *Tubella vesparium* (v Martens) from Borneo, from which it may be distinguished by its smooth skeleton-spicules and the deeply indented disk of its gemmule-

spicules The skeleton-fibres are also rather less stout By the kindness of Dr Weltner, I have been able to compare types of the two species

TYPE in the Indian Museum

HABITAT —Taken at the edge of the Kanghyi (' great pond ') at Mudon near Moulmein in the Amherst district of Tenasserim The specimens were obtained in March in a dry state and had grown on logs and branches which had evidently been submerged earlier in the year. The name *vesparium* given to the allied species on account of its resemblance to a wasps' nest applies with almost equal force to this Burmese form.

Genus 7. CORVOSPONGILLA, nov.

TYPE †, *Spongilla loricata*, Weltner.

Spongillidæ in which the gemmule-spicules are without a trace of rotulæ and the flesh-spicules have slender cylindrical shafts that bear at or near either end a circle of strong recurved spines The gemmule-spicules are usually stout and sausage-shaped, and the gemmules resemble those of *Stratospongilla* in structure The skeleton is strong and the skeleton-spicules stout, both resembling those of the " genus " *Potamolepis*, Marshall.

As in all other genera of Spongillidæ the structure of the skeleton is somewhat variable, the spicule-fibres of which it is composed being much more distinct in some species than in others The skeleton-spicules are often very numerous and in some cases the skeleton is so compact and rigid that the sponge may be described as stony. The flesh-spicules closely resemble the gemmule-spicules of some species of *Ephydatia* and *Heteromeyenia*.

GEOGRAPHICAL DISTRIBUTION —The species of this genus are probably confined to Africa (whence at least four are known) and the Oriental Region One has been recorded from Burma and another from the Bombay Presidency.

Key to the Indian Species of Corvospongilla.

I. Gemmule with two layers of gemmule-spicules, those of the inner layer not markedly smaller than those of the outer	*burmanica*, p 123.
II Gemmule with two layers of gemmule-spicules, the outer of which contains spicules of much greater size than the inner .	*lapidosa*, p 124

† Potts's *Spongilla novæ-terræ* from Newfoundland and N America cannot belong to this genus although it has similar flesh-spicules, for, as Weltner has pointed out (*op. cit supra* p 126), the gemmule-spicules are abortive rotulæ This is shown very clearly in the figure published by Petr (Rozp Ceske Ak Praze, Trida ii, pl ii, figs 27, 28, 1899), who assigns the species to *Heteromeyenia* Weltner places it in *Ephydatia*, and it seems to be a connecting link between the two genera It has been suggested that it is a hybrid (Traxler, Termes Fuzetek, xxi, p 314, 1898)

22 **Corvospongilla burmanica** * (*Kirkpatrick*) (Plate II, fig 5)

Spongilla loricata var *burmanica*, Kirkpatrick, Rec Ind Mus ii, p 97, pl ix (1908)

Sponge forming a shallow sheet, hard, not very strong, of a pale brownish colour; the surface irregularly spiny, the oscula small but conspicuous, circular, raised on little turret-like eminences; the external membrane adhering closely to the sponge

Skeleton dense but by no means regular; the network composed largely of single spines, thick radiating fibres distinguishable in the upper part of the sponge

Spicules Skeleton-spicules smooth, not very stout, amphistrongylous, occasionally a little swollen at the ends, often with one or more fusiform swellings, measuring on an average about 0 27 × 0 0195 mm Flesh-spicules with distinct rotules, the recurved spines numbering 4 to 6, measuring about $\frac{1}{7}$ the length of the spicules; the shaft by no means strongly curved, their length from 0 03–0 045 mm Gemmule-spicules amphioxous, as a rule distinctly curved, sometimes swollen at the ends, covered regularly but somewhat sparsely with fine spines, not measuring more than 0 49 × 0 078 mm

Gemmules strongly adherent, arranged in small groups, either single or double, when single spherical, when double oval, each gemmule or pair of gemmules covered by two layers of gemmule-spicules bound together in chitinous substance, the inner layer on the inner coat of the gemmule, the outer one separated from it by a space and in contact with the outer cage of skeleton-spicules, the size of the gemmule-spicules variable in both layers, external to the outer layer a dense cage of skeleton-spicules, foraminal tubule short, cylindrical.

This sponge is closely related to *S loricata*, Weltner, of which Kirkpatrick regards it as a variety. "The main difference," he writes, "between the typical African form and the Burmese variety consists in the former having much larger microstrongyles (83 × 15 7 μ [0 83 × 0 157 mm]) with larger and coarser spines, . . Judging from Prof Weltner's sections of gemmules, these bodies lack the definite outer shell of smooth macrostrongyles [blunt skeleton-spicules], though this may not improbably be due to the breaking down and removal of this layer A further difference consists in the presence, in the African specimen, of slender, finely spined strongyles [amphistrongyli], these being absent in the Burmese form, though perhaps this fact is not of much importance"

TYPE in the British Museum, a piece in the Indian Museum.

HABITAT —Myitkyo, head of the Pegu-Sittang canal, Lower Burma (*E. W. Oates*).

BIOLOGY.—The sponge had grown over a sheet of the polyzoon *Hislopia lacustris* Carter (see p. 204), remains of which can be detected on its lower surface.

"Mr. E W Oates, who collected and presented the sponge, writes that the specimen was found encrusting the vertical and horizontal surfaces of the bottom beam of a lock gate, where it covered an area of six square feet The beam had been tarred several times before the sponge was discovered The portion of the gate on which the sponge was growing was submerged from November to May for eight hours a day at spring tides, but was entirely dry during the six days of neap tides From May to October it was constantly submerged The sponge was found in April Although the canal is subject to the tides, the water at the lock is always fresh The colour of the sponge during life was the same as in its present condition"

23 Corvospongilla lapidosa * (*Annandale*)

Spongilla lapidosa Annandale, Rec Ind Mus ii, pp 25, 26, figs 3, 4, 5 (1908)

The *sponge* forms a thin but extremely hard and resistant crust the surface of which is either level, slightly concave, or distinctly corrugated, occasional groups of spicules project from it, but their arrangement is neither so regular nor so close as is the case in *C burmanica* The dermal membrane adheres closely to the sponge The oscula are small, some of them are raised above the general surface but not on regular turret-shaped eminences. The colour is grey or black There is a thick chitinous membrane at the base of the sponge

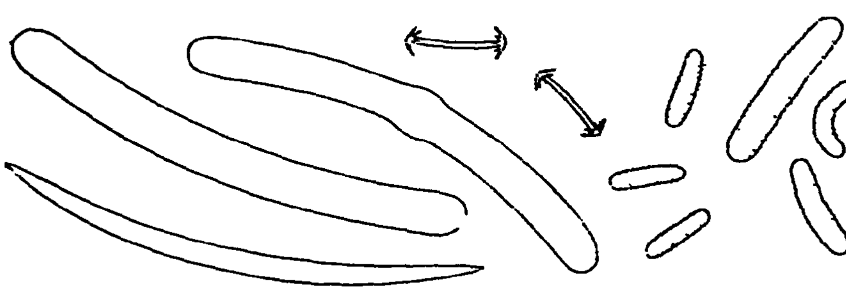


Fig 26 —Spicules of *Corvospongilla lapidosa* (from type specimen), × 240

The *skeleton* is extremely dense owing to the large number of spicules it contains, but almost structureless, broad vertical groups of spicules occur but lack spongin and only traverse a small part of the thickness of the sponge, their position is irregular The firmness of the skeleton is due almost entirely to the interlocking of individual spicules At the base of the sponge the direction of a large proportion of the spicules is horizontal or nearly horizontal, the number arranged vertically being much greater in the upper part

Spicules. The skeleton-spicules are sausage-shaped and often a little swollen at the ends or constricted in the middle. A large proportion are twisted or bent in various ways, and a few bear irregular projections or swellings. The majority, however, are quite smooth. Among them a few more or less slender, smooth amphioxi occur but these are probably immature spicules. The length and curvature of the amphistrongyli varies considerably, but the average measurments are about 0.28×0.024 mm. The flesh-spicules also vary greatly in length and in the degree to which their shafts are curved. At first sight it seems to be possible to separate them into two categories, one in which the shaft is about 0.159 mm long, and another in which it is only 0.05 mm or even less, and groups of birotulates of approximately the same length often occur in the interstices of the skeleton. Spicules of all intermediate lengths can, however, be found. The average diameter of the shaft is 0.0026 mm and of the rotula 0.0106 mm, and the rotula consists of from 6 to 8 spines. The gemmule-spicules vary greatly in size, the longest measuring about 0.08×0.014 and the smallest about 0.034×0.007 or even less. There appears to be in their case an even more distinct separation as regards size than there is in that of the flesh-spicules, but here again intermediate forms occur. They are all stout, more or less blunt, and more or less regularly covered with very short spines, most of them are distinctly curved, but some are quite straight.

Gemmules. The gemmules are firmly adherent to the support of the sponge, at the base of which they are congregated in groups of four or more. They vary considerably in size and shape, many of them being asymmetrical and some elongate and sausage-shaped. The latter consist of single gemmules and not of a pair in one case. Extreme forms measure 0.38×0.29 and 0.55×0.25. Each gemmule is covered with a thick chitinous membrane in close contact with its wall and surrounding it completely. This membrane is full of spicules arranged as in a mosaic, most or all of them belong to the smaller type, and as a rule they are fairly uniform in size. Separated from this layer by a considerable interval is another layer of spicules embedded in a chitinous membrane which is in continuity with the basal membrane of the sponge. The spicules in this membrane mostly belong to the larger type and are very variable in size, mingled with them are often a certain number of birotulate flesh-spicules. The membrane is in close contact with a dense cage of skeleton-spicules arranged parallel to it and bound together by chitinous substance. The walls of this cage, when they are in contact with those of the cages of other gemmules, are coterminous with them. There is a single depressed aperture in the gemmules, as a rule situated on one of the longer sides.

This sponge is distinguished from *C. burmanica* not only by differences in external form, in the proportions of the spicules and the structure of the skeleton, but also by the peculiar nature of the armature of the gemmule. The fact that birotulate spicules

are often found in close association with them, is particularly noteworthy

TYPE in the Indian Museum

GEOGRAPHICAL DISTRIBUTION —This sponge has only been found in the Western Ghats of the Bombay Presidency. *Localities* —Igatpuri Lake and the R Godaveri at Nasik

BIOLOGY.—There is a remarkable difference in external form between the specimens taken in Igatpuri and those from Nasik, and this difference is apparently due directly to environment In the lake, the waters of which are free from mud, the sponges were growing on the lower surface of stones near the edge They formed small crusts not more than about 5 cm (2 inches) in diameter and of a pale greyish colour. Their surface was flat or undulated gently, except round the oscula where it was raised into sharply conical eminences with furrowed sides The specimens from Nasik, which is about 30 miles from Igatpuri, were attached, together with specimens of *Spongilla cinerea* and *S. indica*, to the sides of a stone conduit full of very muddy running water They were black in colour, formed broad sheets and were markedly corrugated on the surface Their oscula were not raised on conical eminences and were altogether most inconspicuous The skeleton was also harder than that of sponges from the lake

In the lake *C lapidosa* was accompanied by the gemmules of *Spongilla bombayensis*, but it is interesting that whereas the latter sponge was entirely in a resting condition, the former was in full vegetative vigour, a fact which proves, if proof were necessary, that the similar conditions of environment do not invariably have the same effect on different species of Spongillidæ.

APPENDIX TO PART I.

Form of Uncertain Position.

(Plate I, fig. 4.)

On more than one occasion I have found in my aquarium in Calcutta small sponges of a peculiar type which I am unable to refer with certainty to any of the species described above Fig 4, pl I, represents one of these sponges They are never more than about a quarter of an inch in diameter and never possess more than one osculum They are cushion-shaped, colourless and soft The skeleton-spicules are smooth, sharply pointed, moderately slender and relatively large They are arranged in definite vertical groups, which project through the dermal membrane, and in irregular transverse formation Small spherical gemmules are present but have only a thin chitinous covering without spicules or foramen

These sponges probably represent an abnormal form of some well-known species, possibly of *Spongilla carteri*. I have seen nothing like them in natural conditions

PART II.

FRESHWATER POLYPS

(HYDRIDA).

INTRODUCTION TO PART II.

I.

The Phylum Cœlenterata and the Class Hydrozoa

The second of the great groups or phyla into which the metazoa are divided is the Cœlenterata, in which are included most of the animals commonly known as zoophytes, and also the corals, sea-anemones and jelly-fish. These animals are distinguished from the sponges on the one hand and from the worms, molluscs, arthropods, vertebrates, etc, on the other by possessing a central cavity (the cœlenteron or "hollow inside") the walls of which are the walls of the body and consist of *two* layers of cells separated by a structureless, or apparently structureless, jelly This cavity has as a main function that of a digestive cavity.

An ideally simple cœlenterate would not differ much in general appearance from an olynthus (p 27), but it would have no pores in the body-wall and its upper orifice would probably be surrounded by prolongations of the body-wall in the form of tentacles There would be no collar-cells, and the cells of the body generally would have a much more fixed and definite position and more regular functions than those of any sponge The most characteristic of them would be the so-called cnidoblasts Each of these cells contains a capsule * from which a long thread-like body can be suddenly uncoiled and shot out

The simplest in structure of the cœlenterates are those that constitute the class Hydrozoa In this class the primitive central cavity is not divided up by muscular partitions and there is no folding in of the anterior part of the body to form an œsophagus or stomatodæum such as is found in the sea-anemones and coral

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* Similar capsules are found in the tissues of certain worms and molluscs, but there is the strongest evidence that these animals, which habitually devour cœlenterates, are able to swallow the capsules uninjured and to use them as weapons of defence (see Martin, Q J Micro Sci London, lii, p 261, 1908, and Grosvenor, Proc Roy Soc London, lxxii, p 462, 1903) The "trichocysts" of certain protozoa bear a certain resemblance to the nettle-cells of cœlenterates and probably have similar functions

polyps In many species and genera the life-history is complex, illustrating what is called the alternation of generations That is to say, only alternate generations attain sexual maturity, those that do so being produced as buds from a sexless generation, which itself arises from the fertilized eggs of a previous sexual generation The sexual forms as a rule differ considerably in structure from the sexless ones, many medusæ are the sexual individuals in a life-cycle in which those of the sexless generation are sedentary

An excellent general account of the cœlenterates will be found in the Cambridge Natural History, vol i (by Prof Hickson)

Structure of Hydra

Hydra, the freshwater polyp, is one of the simplest of the Hydrozoa both as regards structure and as regards life-history Indeed, it differs little as regards structure from the ideally simple cœlenterate sketched in a former paragraph, while its descent is direct from one polyp to another, every generation laying its own eggs * The animal may be described as consisting of the following parts —(1) an upright (or potentially upright) column or body, (2) a circle of contractile tentacles at the upper extremity of the column, (3) an oral disk or peristome surrounding the mouth and surrounded by the tentacles, and (4) a basal or aboral disk at the opposite extremity The whole animal is soft and naked The column, when the animal is at rest, is almost cylindrical in some forms but in others has the basal part distinctly narrower than the upper part It is highly contractile and when contracted sometimes assumes an annulate appearance, but as a rule the external surface is smooth

The tentacles vary in number, but are never very numerous They are disposed in a single circle round the oral disk and are hollow, each containing a prolongation of the central cavity of the column Like the column but to an even greater degree they are contractile, and in some forms they are capable of great elongation They cannot seize any object between them, but are able to move in all directions

The disk that surrounds the mouth, which is a circular aperture, is narrow and can to some extent assume the form of a conical proboscis, although this feature is never so marked as it is in some hydroids The basal disk is even narrower and is not splayed out round the edges

A section through the body-wall shows it to consist of the three typical layers of the cœlenterates, viz, (i) an outer cellular layer of comparatively small cells, the ectoderm, (ii) an intermediate,

* The statement is not strictly accurate as regards the Calcutta phase of *H vulgaris*, for the summer brood apparently does not lay eggs but reproduces its species by means of buds only This state of affairs, however, is probably an abnormality directly due to environment

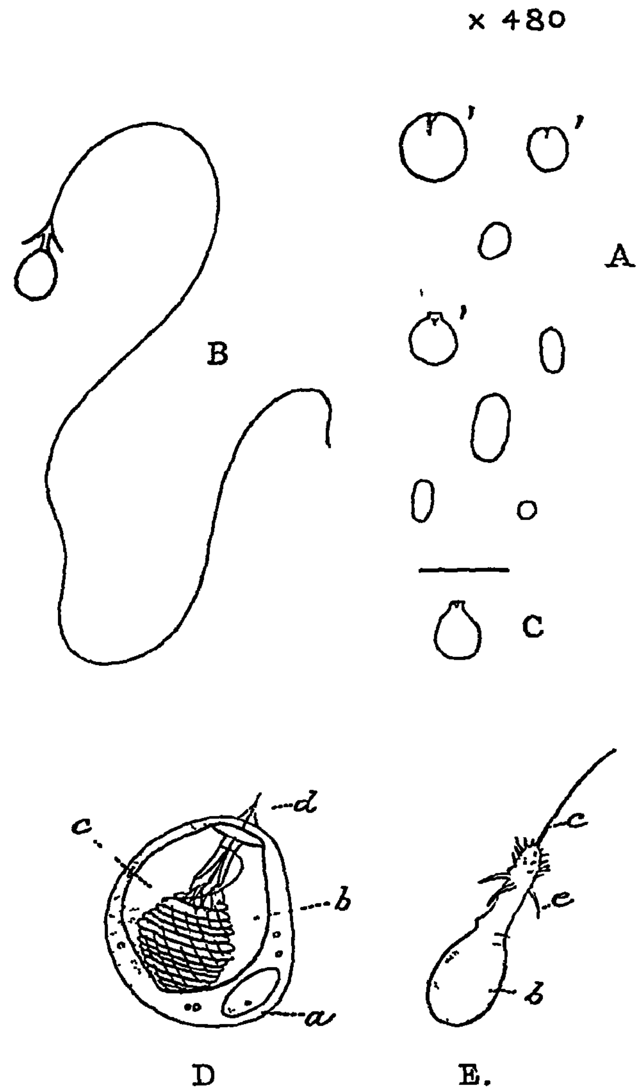


Fig 27 —Nettle-cells of *Hydra*

A=capsules from nettle-cells of a single specimen of the summer phase of *H vulgaris* from Calcutta, ×480 figures marked with a dash represent capsules with barbed threads B=a capsule with the thread discharged, from the same specimen, ×480 C=capsule with barbed thread, from a specimen of *H oligactis* from Lahore D=undischarged nettle-cell of *H vulgaris* from Europe (after Nussbaum, highly magnified) E=discharged capsule of the same (after the same author) *a* = cnidoblast, *b*=capsule, *c*=thread, *d*=cnidocil Only the base of the thread is shown in E

structureless or apparently structureless layer, the mesoglœa or "central jelly", and (iii) an internal layer or endoderm consisting of relatively large cells. The cells of the ectoderm are not homogeneous. Some of them possess at their base narrow and highly contractile prolongations that exercise the functions of muscles Others are gland-cells and secrete mucus, others have round their margins delicate ramifying prolongations and act as nerve-cells Sense-cells, each of which bears on its external surface a minute projecting bristle, are found in connection with the nerve-cells, and also nettle-cells of more than one type

The mesoglœa is very thin

The endoderm consists mainly of comparatively large cells with polygonal bases which can be seen from the external surface of the column in colourless individuals Their inner surface is amœboid and in certain conditions bears one or more vibratile cilia or protoplasmic lashes Nettle-cells are occasionally found in the endoderm, but apparently do not originate in this layer

The walls of the tentacles do not differ in general structure from those of the column, but the cells of the endoderm are smaller and the nematocysts of the ectoderm more numerous, and there are other minor differences

A more detailed account of the anatomy of *Hydra* will be found in any biological text-book, for instance in Parker's Elementary Biology, but it is necessary here to say something more as regards the nettle-cells, which are of great biological and systematic importance.

A nettle-cell of the most perfect type and the structures necessary to it consist of the following parts —

(1) A true cell (the cnidoblast), which contains—
(2) a delicate capsule full of liquid,
(3) a long thread coiled up in the capsule and
(4) a cnidocil or sensory bristle, which projects from the external surface of the cnidoblast

A nerve-cell is associated with each cnidoblast

In *Hydra* the nettle-cells are of two distinct types, in one of which the thread is barbed at the base, whereas in the other it is simple Both types have often two or more varieties and intermediate forms occur, but generally speaking the capsules with simple threads are much smaller than those with barbed ones The arrangement of the nettle-cells is not the same in all species of *Hydra*, but as a rule they are much more numerous in the tentacles than elsewhere on the body, each large cell being surrounded by several small ones The latter are always much more numerous than the former

Capture and Ingestion of Prey Digestion

The usual food of *Hydra* consists of small insect larvæ, worms, and crustacea, but the eggs of fish are also devoured. The method in which prey is captured and ingested has been much disputed, but the following facts appear to be well established

If a small animal comes in contact with the tentacles of the polyp, it instantly becomes paralysed. If it adheres to the tentacle, it perishes, but if, as is often the case, it does not do so, it soon recovers the power of movement Animals which do not adhere are generally those (such as ostracod crustacea) which have a hard integument without weak spots Nematocysts of both kinds shoot out their threads against prey with considerable violence, the discharge being effected, apparently in response to a chemical stimulus, by the sudden uncoiling of the thread and its eversion from the capsule Apparently the two kinds of threads have different functions to perform, for whereas there is no doubt that the barbed threads penetrate the more tender parts of the body against which they are hurled, there is evidence that the simple threads do not do so but wrap themselves round the more slender parts. Nussbaum (Arch mikr Anat xxix, pl xx, fig 108) figures the tail of a *Cyclops* attacked by *Hydra vulgaris* and shows several simple threads wrapped round the hairs and a single barbed thread that has penetrated the integument Sometimes the cyst adheres to the thread and remains attached to its cnidoblast and to the polyp, but sometimes the thread breaks loose Owing to the large mass of threads that sometimes congregate at the weaker spots in the external covering of an animal attacked (*e g*, at the little sensory pits in the integument of the dorsal surface of certain water-mites) it is often difficult to trace out the whole length of any one thread, and as a thread still attached to its capsule is frequently buried in the body of the prey, right up to the barbs, while another thread that has broken loose from its capsule appears immediately behind the fixed one, it seems as though the barbs, which naturally point towards the capsule, had become reversed. This appearance, however, is deceptive The barbs are probably connected with the discharge of the thread and do not function at all in the same way as those on a spear- or arrow-head, never penetrating the object against which the projectile is hurled Indeed, their position as regards the thread resembles that of the feathers on the shaft of an arrow rather than that of the barb of the head

Adhesion between the tentacles and the prey is effected partly by the gummy secretion of the glands of the ectoderm, which is perhaps poisonous as well as adhesive, and partly by the threads Once the prey is fast and has ceased to struggle, it is brought to the mouth, which opens wide to receive it, by the contraction and the contortions of the tentacles, the column, and the peristome At the same time a mass of transparent mucus from the gastral cavity envelops it and assists in dragging it in. There is some

dispute as to the part played by the tentacles in conveying food into the mouth. My own observations lead me to think that, at any rate so far as *H vulgaris* is concerned, they do not push it in, but sometimes in their contortions they even enter the cavity accidentally

When the food has once been engulfed some digestive fluid is apparently poured out upon it. In *H vulgaris* it is retained in the upper part of the cavity and the soluble parts are here dissolved out, the insoluble parts such as the chitin of insect larvæ or crustacea being ejected from the mouth Digestion is, however, to a considerable extent intracellular, for the cells of the endoderm have the power of thrusting out from their surface lobular masses of their cell-substance in which minute nutritive particles are enveloped and dissolved The movements of the cilia which can also be thrust out from and retracted into these cells, keep the food in the gastral cavity in motion and probably turn it round so as to expose all parts in turn to digestive action Complete digestion, at any rate in the Calcutta form, takes several days to accomplish, and after the process is finished a flocculent mass of colourless excreta is emitted from the mouth

Colour.

In *Hydra viridis*, a species that has not yet been found in India, the green colour is due to the presence in the cells of green corpuscles which closely resemble those of the cells of certain freshwater sponges. They represent a stage in the life-cycle of *Chlorella vulgaris*, Beyerinck *, an alga which has been cultivated independently.

In other species of the genus colour is largely dependent on food, although minute corpuscles of a *dark* green shade are sometimes found in the cells of *H oligactis* In the Calcutta phase of *H vulgaris* colour is due entirely to amorphous particles situated mainly in the cells of the endoderm If the polyp is starved or exposed to a high temperature, these particles disappear and it becomes practically colourless They probably form, therefore, some kind of food-reserve, and it is noteworthy that a polyp kept in the unnatural conditions that prevail in a small aquarium invariably becomes pale, and that its excreta are not white and flocculent but contain dark granules apparently identical with those found in the cells of coloured individuals (p 154)

Berninger † has just published observations on the effect of long-continued starvation on *Hydra* carried out in Germany He finds that the tentacles, mouth, and central jelly disappear, and that a closed "bladder" consisting of two cellular layers remains, but, to judge from his figures, the colour does not disappear in these circumstances

* Bot Zeitung, xlviii (1890) see p 49, *antea*
† Zool Anz. xxxvi, pp 271-279, figs, Oct 1910

Behaviour

Hydra viridis is a more sluggish animal than the other species of its genus and does not possess the same power of elongating its column and tentacles It is, nevertheless, obliged to feed more frequently Wagner (Quart J Micr Sci xlviii, p 586, 1905) found it impossible to use this species in his physiological experiments because it died of starvation more rapidly than other forms This fact is interesting in view of the theory that the green corpuscles in the cells of *H viridis* elaborate nutritive substances for its benefit. *H vulgaris*, at any rate in Calcutta, does not ordinarily capture prey more often than about once in three days

All *Hydræ* (except possibly the problematical *H rubra* of Roux, p 160) spend the greater part of their time attached by the basal disk to some solid object, but, especially in early life, *H vulgaris* is often found floating free in the water, and all the species possess powers of progression They do not, however, all move in the same way *H viridis* progresses by "looping" like a geometrid caterpillar During each forward movement the column is arched downwards so that the peristome is in contact with the surface along which the animal is moving The basal disk is then detached and the column is twisted round until the basal disk again comes in contact with the surface at a point some distance in advance of its previous point of attachment The manœuvre is then repeated *H vulgaris*, when about to move, bends down its column so that it lies almost prone, stretches out its tentacles, which adhere near the tips to the surface (p 153), detaches its basal disk, and then contracts the tentacles The column is dragged forward, still lying almost prone, the basal disk is bent downwards and again attached, and the whole movement is repeated Probably *H oligactis* moves in the same way.

When *H. viridis* is at rest the tentacles and column, according to Wagner, exhibit rhythmical contractions in which those of the buds act in sympathy with those of the parent In *H. vulgaris* no such movements have been observed. This species, however, when it is waiting for prey (p 154) changes the direction of its tentacles about once in half an hour

All species of *Hydra* react to chemical and physical stimuli by contraction and by movements of the column and tentacles, but if the stimuli are constantly repeated, they lose the power to some extent All species are attracted by light and move towards the point whence it reaches them. *H vulgaris*, however, at any rate in India, is more strongly repelled by heat Consequently, if it is placed in a glass vessel of water, on one side of which the sun is shining directly, it moves away from the source of the light* But if the vessel be protected

* Mr F H Gravely tells me that this is also the case as regards *H viridis* in England, at any rate if freshly captured specimens are placed overnight in a bottle in a window in such a position that the early morning sunlight falls upon one side of the bottle

from the direct rays of the sun and only a subdued light falls on one side of it, the polyp moves towards that side No species of the genus is able to move in a straight line Wilson (Amer Natural. xxv, p 426, 1891) and Wagner (*op cit supra*) have published charts showing the elaborately erratic course pursued by a polyp in moving from one point to another and the effect of light as regards its movements

If an individual of *H vulgaris* that contains half digested food in its gastral cavity is violently removed from its natural surroundings and placed in a glass of water, the column and tentacles contract strongly for a few minutes The body then becomes greatly elongated and the tentacles moderately so, the tentacles writhe in all directions (their tips being sometimes thrust into the mouth), and the food is ejected.

Reproduction

Reproduction takes place in *Hydra* (i) by means of buds, (ii) by means of eggs, and (iii) occasionally by fission

(a) *Sexual Reproduction*

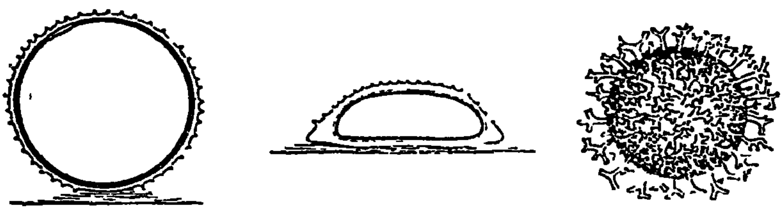
The sexual organs consist of ovaries (female) and spermaries (male) Sometimes the two kinds of organs are borne by the same individual either simultaneously or in succession, but some individuals or races appear to be exclusively of one sex There is much evidence that in unfavourable conditions the larger proportion of individuals develop only male organs

In temperate climates most forms of *Hydra* breed at the approach of winter, but starvation undoubtedly induces a precocious sexual activity, and the same is probably the case as regards other unfavourable conditions such as lack of oxygen in the water and either too high or too low a temperature

Downing states that in N America (Chicago) *H vulgaris* breeds in spring and sometimes as late as December, in Calcutta it has only been found breeding in February and March Except during the breeding-season sexual organs are absent, they do not appear in the same position on the column in all species

The spermaries take the form of small mound-shaped projections on the surface of the column Each consists of a mass of sperm-mother cells, in which the spermatozoa originate in large numbers The spermatozoa resemble those of other animals, each possessing a head, which is shaped like an acorn, and a long vibratile tail by means of which it moves through the water In the cells of the spermary the spermatozoa are closely packed together, with their heads pointing outwards towards the summit of the mound through which they finally make their way into the water The aperture is formed by their own movements Downing (Zool Jahrb (Anat) xxi, p 379, 1905) and other authors have studied the origin of the spermatozoa in great detail

The ovaries consist of rounded masses of cells lying at the base of the ectoderm One of these cells, the future egg, grows more rapidly than the others, some or all of which it finally absorbs by means of lobose pseudopodia extruded from its margin It then makes its way by amœboid movements between the cells of the ectoderm until it reaches the surface In *H vulgaris* (Mem Asiat Soc Beng 1, p 350, 1906) the egg is first visible with the aid of a lens as a minute star-shaped body of an intense white colour lying at the base of the ectoderm cells It increases in



B C A

Fig 28 —Eggs of *Hydra* (magnified)
A = egg of *H vulgaris* (after Chun) B = vertical section through egg of *H oligactis*, form A (after Brauer) C = vertical section through egg of *H oligactis*, form B (after Brauer)

size rapidly, gradually draws in its pseudopodia (the rays of the star) and makes its way through the ectoderm to the exterior. The process occupies not more than two hours The issuing ovum does not destroy the ectoderm cells as it passes out, but squeezes them together round the aperture it makes Owing to the pressure it exerts upon them, they become much elongated and form a cup, in which the embryo rests on the surface of the parent By the time that the egg has become globular, organic connection has ceased to exist. The embryo is held in position partly by means of the cup of elongated ectoderm cells and partly by a delicate film of mucus secreted by the parent The most recent account of the oogenesis ("ovogenesis") is by Downing (Zool Jahrb (Anat) xxvii, p 295, 1909)

(b) *Budding*

The buds of *Hydra* arise as hollow outgrowths from the wall of the column, probably in a definite order and position in each species The tentacles are formed on the buds much as the buds themselves arise on the column There is much dispute as to the order in which these structures appear on the bud, and Haacke (Jenaische Zeitschr Naturwiss xiv, p 133, 1880) has proposed to distinguish two species, *H. trembleyi* and *H. rœselii*, in accordance with the manner in which the phenomenon is manifested.

It seems probable, however, that the number of tentacles that are developed in the first instance is due, at any rate to some extent, to circumstances, for in the summer brood of *H. vulgaris* in Calcutta five usually appear simultaneously, while in the winter brood of the same form four as a rule do so. Sometimes buds remain attached to their parents sufficiently long to develop buds themselves, so that temporary colonies of some complexity arise, but I have not known this to occur in the case of Indian individuals.

(c) *Fission.*

Reproduction by fission occurs naturally but not habitually in all species of *Hydra*. It may take place either by a horizontal or by a vertical division of the column. In the latter case it may be either equal or unequal. If equal, it usually commences by an elongation in one direction of the circumoral disk, which assumes a narrowly oval form, the tentacles increase in number, and a notch appears at either side of the disk and finally separates the column into two equal halves, each of which is a complete polyp. The division sometimes commences at the base of the column, but this is very rare. Transverse fission can be induced artificially and is said to occur sometimes in natural conditions. It commences by a constriction of the column which finally separates the animal into two parts, the lower of which develops tentacles and a mouth, while the upper part develops a basal disk. Unequal vertical division occurs when the column is divided vertically in such a way that the two resulting polyps are unequal in size. It is apparently not accompanied by any great increase in the number of the tentacles, but probably starts by one of the tentacles becoming forked and finally splitting down the middle.

The question of the regeneration of lost parts in *Hydra* cannot well be separated from that of reproduction by fission. Over a hundred and fifty years ago Trembley found that if a polyp were cut into several pieces, each piece produced those structures necessary to render it a perfect polyp. He also believed that he had induced a polyp that had been turned inside out to adapt itself to circumstances and to reverse the functions and structure of the two cellular layers of its body. In this, however, he was probably mistaken, for there can be little doubt that his polyp turned right side out while not under his immediate observation. Many investigators have repeated some of his other experiments with success in Europe, but the Calcutta *Hydra* is too delicate an animal to survive vivisection and invariably dies if lacerated. It appears that even in favourable circumstances, for a fresh polyp to be formed by artificial fission it is necessary for the piece to contain cells of both cell-layers.

Development of the Egg.

The egg of *Hydra* is said to be fertilized as it lies at the base of the ectoderm, through which the fertilizing spermatozoon bores its way As soon as the egg has emerged from the cells of its parent it begins to split up in such a manner as to form a hollow mass of comparatively large equal cells Smaller cells are separated off from these and soon fill the central cavity Before segmentation begins a delicate film of mucus is secreted over the egg, and within this film the larger cells secrete first a thick chitinous or horny egg-shell and within it a delicate membrane. Development in some cases is delayed for a considerable period, but sooner or later, by repeated division of the cells, an oval hollow embryo is formed and escapes into the water by the disintegration of the egg-shell and the subsequent rupture of the inner membrane Tentacles soon sprout out from one end of the embryo's body and a mouth is formed, the column becomes more slender and attaches itself by the aboral pole to some solid object

Enemies

Hydra seems to have few natural enemies Martin (Q J Micr Sci. London, lii, p 261, 1908) has, however, described how the minute worm *Microstoma lineare* attacks *Hydra* "*rubra*" in Scottish lochs, while the larva of a midge devours *H vulgaris* in considerable numbers in Calcutta tanks (p 156)

Cœlenterates of Brackish Water.

Marine cœlenterates of different orders not infrequently make their way or are carried by the tide up the estuaries of rivers into brackish water, and several species have been found living in isolated lagoons and pools of which the water was distinctly salt or brackish Among the most remarkable instances of such isolation is the occurrence in Lake Qurun in the Fayûm of Egypt of *Cordylophora lacustris* and of the peculiar little hydroid recently described by Mr C L Boulenger as *Mœrisia lyonsi* (Q J Micr Sci London, lii, p 357, pls xxii, xxiii, 1908) In the delta of the Ganges there are numerous ponds which have at one time been connected with estuaries or creeks of brackish water and have become isolated either naturally or by the hand of man without the marine element in their fauna by any means disappearing (p 14) The following species have been found in such ponds —

(a) *Hydrozoa*

(1) *Bimeria vestita*, Wright (1859)

Hincks, Hist Brit Hydr Zooph p 103, pl. xv, fig 2 (1868), Annandale, Rec Ind Mus i, p 141, fig 3 (1907)

This is a European species which has also been found off

S. America It occurs not uncommonly in the creeks that penetrate into the Ganges delta and has been found in pools of brackish water at Port Canning The Indian form is perhaps sufficiently distinct to be regarded as a subspecies The medusoid generation is suppressed in this genus

(2) *Syncoryne filamentata*, Annandale (1907)

Annandale, Rec Ind Mus i, p 139, figs 1, 2 (1907)

Both hydroid and medusæ were found in a small pool of brackish water at Port Canning. The specific name refers to the fact that the ends of the rhizomes from which the polyps arise are frequently free and elongate, for the young polyp at the tip apparently takes some time to assume its adult form.

(3) *Irene ceylonensis*, Browne (1905).

Browne, in Herdman's Report on the Pearl Fisheries of Ceylon, iv, p 140, pl iii, figs 9–11 (1905), Annandale, Rec. Ind Mus i, p. 142, fig 4 (1907)

The medusa was originally taken off the coast of Ceylon, while the hydroid was discovered in ponds of brackish water at Port Canning It is almost microscopic in size

The first two of these species belong to the order Gymnoblastea (Anthomedusæ) and the third to the Calyptoblastea (Leptomedusæ)

(b) *Actinozoa*

(4) *Sagartia schilleriana*, Stoliczka (1869)

S schilleriana, Stoliczka, Journ As Soc Beng (2) xxxviii, p 28, pls x, xi (1869), *Metridium schillerianum*, Annandale, Rec Ind Mus i, p 47, pl iii (1907)

This sea-anemone, which has only been found in the delta of the Ganges, offers a most remarkable instance of what appears to be rapid adaptation of a species to its environment The typical form, which was described in 1869 by Stoliczka from specimens taken in tidal creeks and estuaries in the Gangetic area and in the ponds at Port Canning, is found attached to solid objects by its basal disk. The race (subsp *exul*), however, that is now found in the same ponds has become elongate in form and has adopted a burrowing habit, apparently owing to the fact that the bottom of the ponds in which it lives is soft and muddy.

In addition to these four species a minute hydroid belonging to the order Gymnoblastea and now being described by Mr J. Ritchie has been taken in the ponds at Port Canning It is a very aberrant form.

FRESHWATER CŒLENTERATES OTHER THAN HYDRA.

Hydra is the only genus of cœlenterates as yet found in fresh water in India, but several others have been discovered in other countries They are —

(1) *Cordylophora lacustris*, Allman (1843).

Hincks, Hist Brit Hydr Zooph p 16, pl iii, fig 2 (1868)

This is a branching hydroid that does not produce free medusæ. It forms bushy masses somewhat resembling those formed by a luxuriant growth of *Plumatella fruticosa* (pl iii, fig. 1) in general appearance *C lacustris* is abundant in canals, rivers, and estuaries in many parts of Europe and has recently been found in the isolated salt lake Birket-el-Qurun in the Fayûm of Egypt

(2) *Cordylophora whiteleggei*, v Lendenfeld (1887)

Zool Jahrb. ii, p 97 (1887)

A species or race of much feebler growth; as yet imperfectly known and only recorded from fresh water in Australia.

Cordylophora is a normal genus of the class Hydrozoa and the order Gymnoblastea, the next four genera are certainly Hydrozoa, but their affinities are very doubtful

(3) *Microhydra ryderi*, Potts (1885)

Potts, Q J Micr Sci London, l, p 623, pls xxxv, xxxvi, Browne, *ibid* p 635, pl xxxvii (1906)

This animal, which has been found in N America and in Germany, possesses both an asexual hydroid and a sexual medusoid generation. The former reproduces its species by direct budding as well as by giving rise, also by a form of budding, to medusæ that become sexually mature. The hydroid has no tentacles

(4) *Limnocodium sowerbii*, Lankester (1880).

Lankester, Q J Micr Sci London, xx, p 351, pls xxx, xxxi (1880), Fowler, *ibid* xxx, p 507, pl xxxii (1890)

There is some doubt as to the different stages in the life-cycle of this species The medusa has been found in tanks in hot-houses in England, France and Germany, and a minute hydroid closely resembling that of *Microhydra ryderi* has been associated with it provisionally.

(5) *Limnocodium kawaii*, Oka (1907)

Oka, Annot Zool Japon vi, p 219, pl. viii (1907).

Only the medusa, which was taken in the R Yang-tze-kiang, is as yet known

(6) *Limnocnida tanganyikæ*, Bohm (1889)

R T Gunther, Ann Nat Hist (6) xi, p 269, pls xiii, xiv (1893)

Only the medusa, which is found in Lake Tanganyika, Lake Victoria Nyanza and the R Niger, has been found and it is doubtful whether a hydroid generation exists

(7) *Polypodium hydriforme*, Ussow (1885)

Morph Jahrb xii, p 137 (1887).

Two stages in this peculiar hydroid, which is found in the R Volga, are known, (*a*) a spiral ribbon-like form parasitic on the eggs of the sterlet (*Acipenser ruthenus*), and (*b*) a small *Hydra*-like form with both filamentous and club-shaped tentacles The life-history has not yet been worked out †

II

History of the Study of Hydra

Hydra was discovered by Leeuwenhoek at the beginning of the eighteenth century and had attracted the attention of several skilful and accurate observers before that century was half accomplished. Among them the chief was Trembley, whose "Mémoires pour servir à l'histoire d'un genre de Polype d'eau douce" * was published at Paris 1744, and is remarkable not only for the extent and accuracy of the observations it enshrines but also for the beauty of its plates Baker in his work entitled "An attempt towards a natural history of the Polyp" * (London, 1743) and Rosel von Rosenhof in the third part of his "Insecten-Belustigung" (Nurenberg, 1755) also made important contributions to the study of the physiology and structure of *Hydra* about the same period Linné invented the name *Hydra*, and in his "Fauna Sueica" and in the various editions of his "Systema Naturæ" described several forms in a manner that permits some of them to be recognized, but Linné did not distinguish between the true *Hydra* and other soft sessile Cœlenterates, and it is to Pallas ("Elenchus Zoophytorum," 1766) that the credit properly belongs of reducing the genus to order It is a tribute to his insight that three of the four species he described are still accepted as "good" by practically all students of the Cœlenterates, while the fourth was a form that he had not himself seen

In the nineteenth century the freshwater polyp became a favourite object of biological observation and was watched and examined by a host of observers, among the more noteworthy of whom were Kleinenberg, Nussbaum, and Brauer, who has since the beginning of the present century made an important contribution to the taxonomy of the genus

† Since this was written, Lippen has described a third stage in the life-history of *Polypodium* (Zool Anz Leipzig, xxxvii, Nr 5, p 97 (1911))

Bibliography of Hydra.

Hydra has been examined by thousands of students in biological laboratories all over the civilized world, and the literature upon it is hardly surpassed in magnitude by that on any other genus but *Homo* The following is a list of a few of the more important general memoirs and of the papers that refer directly to Asiatic material A systematic bibliography is given by Bedot in his "Materiaux pour servir à l'Histoire des Hydroides," Rev Suisse Zool xviii, fasc 2 (1910)

(a) *General*

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1744 Trembley, "Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce" * (Paris)

1755 Rosel von Rosenhof, "Insecten-Belustigung iii, Hist Polyporum"

1766 Pallas, "Elenchus Zoophytorum"

1844 Laurent, "Rech sur l'Hydre et l'Eponge d'eau douce" ("Voy de la Bonite, Zoophytologie")

1847 Johnston, "A History of the British Zoophytes" (2nd edition)

1868 Hincks, "History of British Hydroid Zoophytes"

1872 Kleinenberg, "Hydra Eine Anatomisch Entwicklungsgeschichtliche Untersuchung"

1882 Jickeli, "Der Bau der Hydroidpolypen," Morph Jahrb viii, p 373

1887 Nussbaum, "Ueber die Theilbarkeit der lebendigen Materie II Mittheilung Beitrage zur Naturgeschichte des Genus Hydra," Arch mikr Anat Bonn, xxix, p. 265

1891 Brauer, "Uber die Entwicklung von Hydra," Zeitschr wiss Zool Leipzig, lii, p 169

1892 Chun, "Cœlenterata (Hohlthiere)," in Bronn's Thier-Reichs II (2)

1905 Downing, "The spermatogenesis of Hydra," Zool Jahrb (Anat) xxi, p 379

1908 Brauer, "Die Benennung und Unterscheidung der Hydra-Arten," Zool Anz. xxxiii, p 790

1909 Frischholz, "Biologie und Systematik im Genus Hydra," Braun's Annal Zool (Wurzburg) iii, p 105.

1910 Berninger, "Uber Einwirkung des Hungers auf Hydra," Zool Anz xxxvi, p 271

(b) *Asiatic References*

1894 Richard, "Sur quelques Animaux inférieurs des eaux douces du Tonkin (Protozoaires, Rotifères, Entomostracés)," Mém Soc zool France, vii, p 237

1904 Von Daday, "Mikroskopische Susswasserthiere aus Turkestan," Zool Jahrb (Syst) xix, p 469

1906 ANNANDALE, "Notes on the Freshwater Fauna of India No IV *Hydra orientalis* and its bionomical relations with other Invertebrates," J Asiat Soc Bengal (new series), ii, p 109

1906 ANNANDALE, "The Common *Hydra* of Bengal its Systematic Position and Life History," Mem As Soc Bengal, i, p 339

1907 ANNANDALE, "Notes on the Freshwater Fauna of India No X *Hydra orientalis* during the Rains," J Asiat Soc Bengal (new series), iii, p 27

1907. ANNANDALE, "Notes on the Freshwater Fauna of India No XI. Preliminary Note on the occurrence of a Medusa (*Irene ceylonensis*, Browne) in a brackish pool in the Ganges Delta and on the Hydroid Stage of the species," J Asiat Soc Bengal (new series), iii, p 79

1907 WILLEY, "Freshwater Sponge and Hydra in Ceylon," Spolia Zeylan Colombo, iv, p. 184

1908 ANNANDALE, "Observations on specimens of *Hydra* from Tibet, with notes on the distribution of the genus in Asia," Rec Ind Mus ii, p 311

1910 POWELL, "Lessons in Practical Biology for Indian Students" (Bombay)

1910 LLOYD, "An Introduction to Biology for Students in India" (London).

GLOSSARY OF TECHNICAL TERMS USED IN PART II

Aboral (or *basal*) *disk*	The disk by means of which a free polyp attaches itself to external objects
Cnidoblast	The living cell of the nematocyst or nettle-cell (*q v*)
Cnidocil	A minute bristle that projects on the surface in connection with a nettle-cell (*q v*)
Column	The upright or potentially upright part of a polyp (*q v*)
Ectoderm	The external cell-layer of the body-wall
Endoderm	The internal cell-layer of the body-wall
Green (*chlorophyll*) *corpuscles*	Minute green bodies contained in cells of polyps or other animals and representing a stage in the life-history of an alga (*Chlorella*)
Mesoglœa	The intermediate, gelatinous layer of the body-wall
Nettle-cell (*nematocyst*)	A cell capsule full of liquid in which an eversible thread is coiled up
Oral disk	The eminence that surrounds the mouth and is surrounded by tentacles
Peristome	See "oral disk"
Polyp	An individual cœlenterate of simple structure that is fixed temporarily or permanently by one end of a more or less cylindrical body and possesses a mouth at the other end
Tentacles	Filamentous outgrowths (in *Hydra* hollow) of the body-wall round the mouth

LIST OF THE INDIAN HYDRIDA.

Class HYDROZOA.

Order **ELEUTHEROBLASTEA.**

Family HYDRIDÆ

Genus Hydra, *Linné* (1746)

24 *H. vulgaris*, Pallas (1766).
25 *H. oligactis*, Pallas (1766)

Order ELEUTHEROBLASTEA.

Naked hydrozoa which reproduce their kind by means of buds or eggs, or by fission, without exhibiting the phenomena of alternation of generations

Family HYDRIDÆ.

HYDRAIDÆ, Johnston, Hist Brit Zooph (ed 2) i, p 120 (1847)
HYDRIDÆ, Hincks, Hist Brit Hydroid Zooph p 309 (1868)

Small Eleutheroblastea in which the mouth is surrounded by hollow tentacles Permanent colonies are not formed, but reproduction by budding commonly takes place.

Genus HYDRA, *Linné*

TYPE, *Hydra viridis*, Linné

Freshwater polyps which produce eggs with hard chitinous shells Although habitually anchored by the end of the body furthest from the mouth to extraneous objects, they possess considerable powers of locomotion They are extremely contractile and change greatly from time to time in both form and size

Only three well-established species of the genus, which is universally distributed and occurs only in fresh or brackish * water, can be recognized, namely, *H viridis*, Linné (=*H viridissima*, Pallas), *H vulgaris*, Pallas (=*H grisea*, Linné), and *H oligactis*, Pallas (=*H fusca*, Linné) The two latter occur in India, but *H viridis* does not appear to have been found as yet anywhere in the Oriental Region, although it is common all over Europe and N America and also in Japan The distribution of *H vulgaris* is probably cosmopolitan, but there is some evidence that *H. oligactis* avoids tropical districts, although, under the name *Hydra fusca*, it has been doubtfully recorded as occurring in Tonquin †

The three species may be distinguished from one another by the following key —

[I Colour leaf-green, the cells contain green (chlorophyll) corpuscles of definite form
A Tentacles comparatively stout, habitually shorter than the column, which is cylindrical. Egg-shell without spines, ornamented with a reticulate pattern . *viridis*]

* A small form of *H viridis* (var *bakeri*, Marshall) is found in brackish water in England

† Richard, Mém Soc zool France, vii, p 237 (1894)

II Colour never leaf-green, no chlorophyll corpuscles present in the cells

A Tentacles capable of great elongation but when the animal is at rest never very much longer than the column, which is cylindrical when the gastral cavity is empty Largest nettle-cells almost as broad as long Egg-shell bearing long spines most of which are divided at the tips — *vulgaris*, p 148

B Tentacles, even when the animal is at rest, much longer than the column, the basal part of which, even when the gastral cavity is empty, is constricted Largest nettle-cells considerably longer than broad. Egg-shell smooth or bearing short, simple spines — *oligactis*, p 158

24 Hydra vulgaris, *Pallas*

Polypes de la seconde espèce, Trembley, Mém pour servir à l'histoire d'un genre de polypes d'eau douce*, pl i, figs 2, 5, pl vi, figs 2, 8, pl viii, figs 1–7, pl xi, figs 11–13 (1744)

Rosel von Rosenhof, Insecten-Belustigung, iii, Hist Polyporum, pls lxxvi, lxxvii, lxxix–lxxxiii (1755)

? *Hydra polypus*, Linné, Fauna Suecica, p 542 (1761)

Hydra vulgaris, Pallas, Elenchus Zoophytorum, p. 30 (1766)

? *Hydra attenuata*, *id*, *ibid* p 32

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Hydra aurantiaca, Kleinenberg, Hydra, p 70, pl i, fig 1, pl iii, fig 10 (1872)

Hydra trembleyi, Haacke, Zool Anz Leipzig, ii, p. 622 (1879)

Hydra grisea, Jickeli, Morph Jahrb viii, p 391, pl xviii, fig 2 (1883)

Hydra grisea, Nussbaum, Arch mikr Anat Bonn, xxix, p 272, pl xiii, pl xiv, figs 33, 37, 47 (1887)

? *Hydra hexactinella*, v Lendenfeld, Zool. Jahrb Jena, ii, p 96, pl vi, figs 13, 14 (1887)

? *Hydra hexactinella*, *id*, Proc Linn Soc N S Wales, x, p 678, p xlviii, figs 1–4 (1887)

Hydra grisea, Brauer, Zeit wiss Zool Leipzig, lii, p 169 (1891)

Hydra grisea, Chun, in Bronn's Thier-Reichs, ii (2), pl ii, figs 2 *b*, 2 *c*, 5 (1892)

Hydra grisea, Downing, Zool Jahrb (Anat) Jena, xxi, p 381 (1905)

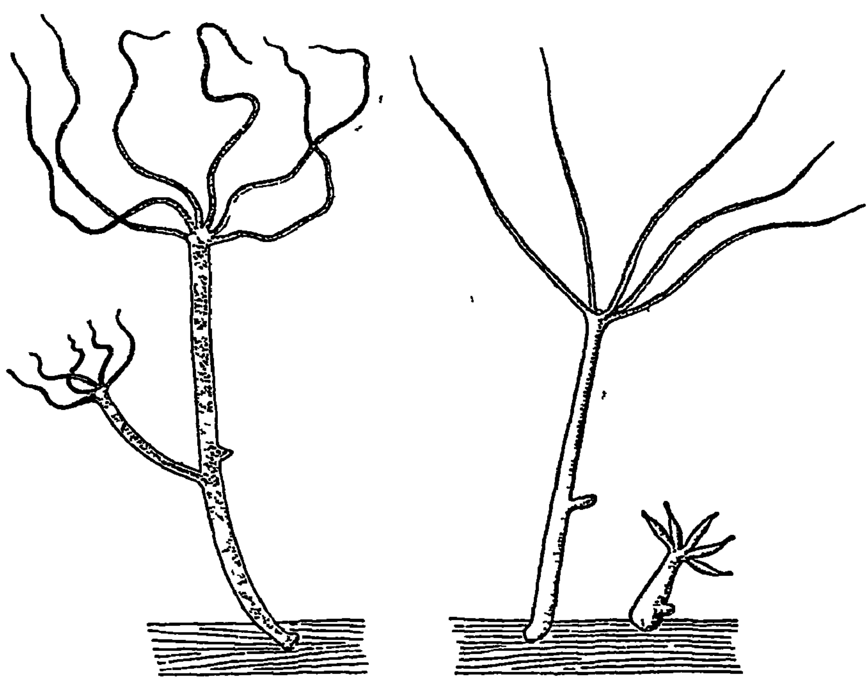
Hydra orientalis, Annandale, J. Asiat Soc Bengal, (new series) i, 1905, p 72.

Hydra orientalis, *id.*, *ibid.* (new series) ii, 1906, p. 109
Hydra orientalis, *id.*, Mem. Asiat. Soc. Bengal, i, p. 340 (1906)
? *Hydra orientalis*, Willey, Spol. Zeylan. Colombo, iv, p. 185 (1907)
Hydra grisea, Weltner, Arch. Naturg. Berlin, lxxiii, i, p. 475 (1907)
Hydra vulgaris, Brauer, Zool. Anz. xxxiii, p. 792, fig. 1 (1908)
Hydra orientalis, Annandale, Rec. Ind. Mus. ii, p. 312 (1908)
Hydra grisea, Frischholz, Braun's Zool. Annal. (Wurzburg), iii, pp. 107, 134, &c., figs. 1 and 10–17 (1909)
Hydra grisea, *id.*, Biol. Centralbl. Berlin, xxix, p. 184 (1909)
Hydra vulgaris, Brauer, Die Susswasserfauna Deutschlands, xix, p. 192, figs. 336–338 (1909)
Hydra pentactinella, Powell, Lessons in Practical Biology for Indian Students, p. 24 (Bombay, 1910)

Phase *orientalis* *, Annandale.

Colour variable, in summer usually pale, in winter either deep orange, dull brown, or dark green. The cells do not contain spherical or oval coloured bodies.

Column slender and capable of great elongation, normally almost cylindrical, but when containing food often shaped like a



A B

Fig. 29.—*Hydra vulgaris*, from Calcutta (phase *orientalis*).
A=winter brood, B=summer brood, the same individual in an expanded and a contracted condition. B is more highly magnified than A.

wine-glass. The surface is thickly set with nettle-cells the cnidocils of which give it an almost hirsute appearance under the

microscope When extended to the utmost the column is sometimes nearly 30 mm ($1\frac{1}{5}$ inches) long, but more commonly it is about half that length or even shorter

Tentacles usually 4–6, occasionally 8 They are always slender except when they are contracted, then becoming swollen at the base and slightly globular at the tip If the animal is at rest they are not very much longer than the body, but if it is hungry or about to move from one place to another they are capable of very great extension, often becoming like a string of minute beads (the groups of nettle-cells) strung on an invisible wire

Nettle-cells The capsules with barbed threads (fig 27, p 131) are very variable in size, but they are invariably broad in proportion to their length and as a rule nearly spherical In a *Hydra* taken in Calcutta during the winter the largest capsules measured (unexploded) 0 0189 mm in breadth and 0 019 in length, but in summer they are smaller (about 0 012 mm in breadth) Smaller capsules with barbed threads always occur The barbed threads are very long and slender At their base they bear a circle of stout and prominent spines, usually 4 in number, above these there are a number of very small spines, but the small spines are usually obscure Malformed corpuscles are common The capsules with unbarbed threads are very nearly as broad at the distal as at the proximal end, they are broadly oval with rounded ends

Reproductive organs The reproductive organs are confined to the upper part of the body In India eggs (fig 28, p 137) are seldom produced They sometimes appear, however, at the beginning of the hot weather In form they are spherical, and their shell bears relatively long spines, which are expanded, flattened and more or less divided at the tip The part of the egg that is in contact with the parent-polyp is bare Spermaries are produced more readily than ovaries, they are mammillate in form and number from 4 to 24 Ovaries and spermaries have not been found on the same individual

Buds are confined to a narrow zone nearer the base than the apex of the column Rarely more than 2 are produced at a time, and I have never seen an attached bud budding In winter 5 tentacles are as a rule produced simultaneously, and in summer 4 In the former case a fifth often makes its appearance before the bud is liberated

In Calcutta two broods can be distinguished, a cold-weather brood, which is larger, stouter, and more deeply coloured, produces buds more freely, has larger nematocysts, and as a rule possesses 6 tentacles, and a hot weather brood, which is smaller, more slender and paler, produces buds very sparingly, has smaller nematocysts, and as a rule possesses only 4 or 5 tentacles Only the cold-weather form is known to become sexually mature There is evidence, however, that in those parts of India which enjoy a more uniform tropical climate than Lower Bengal, polyps found at all times of year resemble those found in the hot weather in Calcutta, and sometimes produce spermatozoa or eggs

I have recently had an opportunity of comparing specimens of the Calcutta hot-weather form with well-preserved examples of *H vulgaris*, Pallas (=*H grisea*, Linn), from England. They differ from these polyps in very much the same way as, but to a greater degree than they do from the winter phase of their own race, and I have therefore no doubt that *H orientalis* is merely a tropical phase of Pallas's species. My description is based on Indian specimens, which seem to differ, so far as anatomy is concerned, from European ones in the following points —

(1) The sexes are invariably distinct;
(2) the nematocysts are invariably smaller

I have seen in Burma an abnormal individual with no tentacles It buds, however, possessed these organs

TYPE None of the older types of *Hydra* are now in existence That of *H orientalis* is, however, in the collection of the Indian Museum

GEOGRAPHICAL DISTRIBUTION —*H vulgaris* is common in Europe and N America and is probably found all over tropical Asia The following are Indian and Ceylon localities —BENGAL, Calcutta and neighbourhood (*Annandale, Lloyd*), Adra, Manbhum district (*Paiva*), Rampur Bhulia on the R Ganges (*Annandale*), Chakradharpur, Chota Nagpur (*Annandale*), Pusa, Bihar (*Annandale*), Puri, Orissa (*Annandale*) MADRAS, sea-beach near Madras town (*Henderson*) BOMBAY, island of Bombay (*Powell*) BURMA, Mandalay, Upper Burma, and Moulmein, N Tenasserim (*Annandale*) CEYLON, Colombo and Peradeniya (*Willey, Green*) Dr A. D. Imms tells me that he has obtained specimens that probably belong to this species in the Jumna at Allahabad

BIOLOGY —In India *H vulgaris* is usually found, so far as my experience goes, in stagnant water In Calcutta it is most abundant in ponds containing plenty of aquatic vegetation, and seems to be especially partial to the plant *Limnanthemum*, which has floating leaves attached to thin stalks that spring up from the bottom, and to *Lemna* (duckweed) Dr. Henderson, however, found specimens in a pool of rain-water on the sea-shore near Madras

There is evidence that each of the two broods which occur in Lower Bengal represents at least one generation, probably it represents more than one, for tentacles are rarely if ever produced after the animal has obtained its full size, and never (or only owing to accident) decrease in number after they have once appeared The winter form is found chiefly near the surface of the water, especially on the roots of duckweed and on the lower surface of the leaves of *Limnanthemum*, but the summer form affects deeper water in shady places, and as a rule attaches itself to wholly submerged plants The latter form is to be met with between March and October, the cold-weather form between October and March, both being sometimes found together at the periods of transition In the unnatural environment of an aquarium, however, individuals of the winter form lose their colour and become attenuated, in these features resembling the

summer form, even in the cooler months. Buds produced in these conditions rarely have more than five tentacles or themselves produce buds freely after liberation

The buds appear in a fixed order and position, at any rate on individuals examined in winter, in specimens of the summer form the position is fixed, but the order is irregular Each quadrant of the column has apparently the power of producing, in a definite zone nearer the aboral pole than the mouth, a single bud, but the buds of the different quadrants are not produced simultaneously. If we imagine that the quadrants face north, south, east, and west, and that the first bud is produced in the north quadrant, the second will be produced in the east quadrant, the third in the south, and the fourth in the west It is doubtful whether more than four buds are produced in the lifetime of an individual, and apparently attached buds never bud in this race The second bud usually appears before the first is liberated, and this is also the case occasionally as regards the third, but it is exceptional for four buds to be present at one time About three weeks usually elapse between the date at which the bud first appears as a minute conical projection on the surface of the parent and that at which it liberates itself This it does by bending down, fixing itself to some solid object by means of the tips of its tentacles, the gland-cells of which secrete a gummy fluid, and then tearing itself free.

Although it is rare for more than two buds to be produced simultaneously, budding is apparently a more usual form of reproduction than sexual reproduction Individuals that bear eggs have not yet been found in India in natural conditions, although males with functional spermaries are not uncommon at the approach of the hot weather The few eggs that I have seen were produced in my aquarium towards the end of the cold weather Starvation, lack of oxygen, and too high a temperature (perhaps also lack of light) appear to stimulate the growth of the male organs in ordinary cases, but perhaps they induce the development of ovaries in the case of individuals that are unusually well nourished.

The spines that cover the egg retain débris of various kinds upon its surface, so that it becomes more or less completely concealed by a covering of fragments of dead leaves and the like even before it is separated from the polyp Its separation is brought about by its falling off the column of the parent Nothing is known of its subsequent fate, but probably it lies dormant in the mud through the hot weather Eggs are sometimes produced that have no shells This is probably due to the fact that they have not been fertilized

Reproduction by fission occurs rarely in the Indian *Hydra*, but both equal and unequal vertical fission have been observed In the case of equal fission the circumoral area lengthens in a horizontal direction, and as many extra tentacles as those the polyp already possesses make their appearance. The mouth then becomes constricted in the middle and notches corresponding to its constriction appear at either side of the upper part of the column. Finally the

whole animal divides into two equal halves in a vertical direction I have only seen one instance of what appeared to be unequal vertical fission—that of a polyp consisting of two individuals still joined together by the basal disk, but one about half the size of the other Each had three well-developed tentacles, and in addition a minute fourth tentacle This was situated on the side opposed to that of the other individual which bore a similar tentacle Transverse fission has not been observed The Indian *Hydra* is a very delicate animal as compared with such a form as *H viridis*, and all attempts to produce artificial fission without killing the polyp have as yet failed

Young individuals are often, and adults occasionally, found floating free in the water, either with the mouth uppermost and the tentacles extended so as to cover as large an area as possible or with the aboral pole at the surface In the former case they float in mid-water, being of nearly the same specific gravity as the water, and are carried about by any movement set up in it In the latter case, however, the base of the column is actually attached to some small object such as the cast skin of a water-flea or to a minute drop of mucus originally given out by the polyp's own mouth, the tentacles either hang downwards or are spread out round the mouth, and the animal is carried about by wind or other agencies acting on the surface

In addition to this passive method of progression the polyp can crawl with considerable rapidity In doing so it bends its column down to the object along which it is about to move in such a way that it lies almost parallel to the surface, the basal disk, however, being still attached The tentacles are then extended and attach themselves near the tips to the surface a considerable distance away Attachment is effected by the secretion of minute drops of adhesive substance from gland-cells The basal disk is liberated and the tentacles contract, dragging the column, which still lies prone, along as they do so The basal disk again affixes itself, the tentacles wrench themselves free, the surface of their cells being often drawn out in the process into pseudopodia-like projections, which of course are not true pseudopodia * but merely projections produced by the mechanical strain The whole action is then repeated The polyp can also pull itself across a space such as that between two stems or leaves by stretching out one of its tentacles, fixing the tip to the object it desires to reach, pulling itself free from its former point of attachment, and dragging itself across by contracting the fixed tentacle The basal disk is then turned round and fixed to the new support

The Indian polyp, like all its congeners, is attracted by light, but it is more strongly repelled by heat Probably it never moves in a straight line, but if direct sunlight falls on one side

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* See Zykoff, Biol Centralbl xviii, p 272 (1898), and Annandale, Rec Ind Mus i, p 67 (1907)

of a glass aquarium, the polyps move away from that side in a much less erratic course than is usually the case. If conditions are favourable, they often remain in one spot for weeks at a time, their buds congregating round them as they are set free. In a natural environment it seems that regular migrations take place in accordance with changes in temperature, for whereas in cool weather many individuals are found adhering to the lower surface of the floating leaves of *Limnanthemum*, few are found in this position immediately after a rise in the thermometer. If the rise is only a small one, they merely crawl down the stems to the end of which the leaves are attached, but as soon as the hot weather begins in earnest, the few that survive make their way to the deepest and most shady part of the pond. In captivity the polyps seek the bottom of any vessel in which they are contained, if sunlight falls on the surface of the water.

The chief function of the tentacles is that of capturing prey. The Indian polyp feeds as a rule in the early morning, before the day has become hot. In an aquarium at any rate, the tentacles are never more than moderately extended during the night. If the polyp is hungry, they are extended to their greatest length in the early morning, and if prey is not captured, they sometimes remain in this condition throughout the day. In these circumstances they hang down or stand up in the water closely parallel to one another, and often curved in the middle as if a current were directed against them. Prey that comes in contact with one of them has little chance of escape, for nematocysts from all the tentacles can be readily discharged against it. Approximately once in half an hour the direction of the tentacles is changed, but I have been unable to observe any regular rhythmical movements of the tentacles or any correlation between those of a parent polyp and the buds still attached to it.

The prey consists chiefly of the young larvæ of midges (Chironomidæ) and may-flies, but small copepod and phyllopod crustacea are also captured.

As soon as the prey adheres firmly to the tentacles and has become paralysed it is brought to the mouth by their contracting strongly and is involved in a mass of colourless mucus extruded from the digestive cavity. Partly by the contraction of muscle-fibres in the body-wall and partly by movements of the mouth itself assisted by the mucus, which apparently remains attached to the walls of the cavity, the food is brought into the mouth. If it is at all bulky, it remains in the upper part of the cavity, the gland-cells pouring out a digestive fluid upon it and so dissolving out soluble substances. A large share of the substances thus prepared falls down to the bottom of the cavity and are there digested by the endoderm cells. The insoluble parts of the food are, however, ejected from the mouth without ever reaching the base of the cavity.

The colour of the polyp appears to be due mainly to the results of digestion. Brown or orange individuals recently captured in

a pond and kept in favourable conditions take three or four days to digest their food, and the excreta ejected from the mouth then take the form of a white flocculent mass. If, however, the same individuals are kept for long in a glass aquarium, they lose their colour, even though they feed readily. Digestion is then a much more rapid process, and the excreta contain minute, irregular, coloured granules, which appear to be identical with those contained in the endoderm cells of individuals that have recently digested a meal fully. Starved individuals are always nearly colourless. It seems, therefore, that in this species colour is due directly to the products of digestion, and that digestion does not take place so fully in unfavourable conditions or at a high temperature as it does in more healthy circumstances. The dark green colour of some polyps is, however, less easily explained. I have noticed that all the individuals which have produced eggs in my aquarium have been of this colour, which they have retained in spite of captivity, whereas individuals that produced spermatozoa often lost their colour completely before doing so, sometimes becoming of a milky white owing to the accumulation of minute drops of liquid in their endoderm cells. Even in green individuals there is never any trace in the cells of coloured bodies of a definite form.

The Indian polyp, unlike European representatives of its species, is a very delicate little animal. In captivity at any rate, three circumstances are most inimical to its life: firstly, a sudden rise in the temperature, which may either kill the polyp directly or cause it to hasten its decease by becoming sexually mature; secondly, the lack of a free current of air on the surface of the aquarium; and thirdly, the growth of a bacterium, which forms a scum on the top of the water and clogs up the interstices between the leaves and stems of the water-plants, soon killing them. If adult polyps are kept even in a shallow opaque vessel which is shut up in a room with closed shutters they generally die in a single night; indeed, they rarely survive for more than a few days unless the vessel is placed in such a position that air is moving almost continuously over its surface. The bacterium to which I allude often almost seals up the aquarium, especially in March and April, in which months its growth is very rapid. Strands of slime produced by it surround the polyp and even enter its mouth. In this event the polyp retracts its tentacles until they become mere prominences on its disk, and shrinks greatly in size. The colouring matter in its body becomes broken up into irregular patches owing to degeneracy of the endoderm cells, and it dies within a few hours.

Hydra in Calcutta is often devoured by the larva of a small midge (*Chironomus fasciatipennis*, Kieffer) common in the tanks from November to February. In the early stages of its larval life this insect wanders free among communities of protozoa (*Vorticella*, *Epistylis*, &c.) and rotifers on which it feeds, but as maturity approaches begins to build for itself a temporary shelter of one

of two kinds, either a delicate silken tunnel the base of which is formed by some smooth natural surface, or a regular tube the base of which is fixed by a stalk situated near the middle of its length to some solid object, while the whole surface is covered with little projections. The nature of the covering appears to depend partly on that of the food-supply and partly on whether the larva is about to change its skin.

I had frequently noticed that tunnels brought from the tank on the under surface of *Limnanthemum* leaves had a *Hydra* fixed to them. This occurred in about a third of the occupied shelters examined. The *Hydra* was always in a contracted condition and often more or less mutilated. By keeping a larva together with a free polyp in a glass of clean water, I have been able to observe the manner in which the polyp is captured and entangled. The larva settles down near the base of its column and commences to spin a tunnel. When this is partially completed, it passes a thread round the polyp's body to which it gives a sharp bite. This causes the polyp to bend down its tentacles, which the larva entangles with threads of silk, doing so by means of rapid, darting movements, for the nettle-cells would prove fatal should they be shot out against its body, which is soft. Its head is probably too thickly coated with chitin to excite their discharge. Indeed, small larvæ of this very species form no inconsiderable part of the food of the polyp, and, so far as my observations go, a larva is always attacked in the body and swallowed in a doubled-up position.

When the *Hydra* has been firmly built into the wall of the shelters and its tentacles fastened down by their bases on the roof, the larva proceeds, sometimes after an interval of some hours, to eat the body, which it does very rapidly, leaving the tentacles attached to its shelter. The meal only lasts for a few minutes; after it the larva enjoys several hours' repose, protected by remains of its victim, which retain a kind of vitality for some time. During this period it remains still, except for certain undulatory movements of the posterior part of the body which probably aid in respiration. Then it leaves the shelter and goes in search of further prey. Its food, even when living in a tunnel, does not consist entirely of *Hydra*. I have watched a larva building its shelter near a number of rotifers, some of which it devoured and some of which it plastered on to its tunnel.

The tubular shelters occasionally found are very much stouter structures than the tunnels, but are apparently made fundamentally of the same materials; and structures intermediate between them and the tunnels are sometimes produced. The larva as a rule fastens to them branches detached from living colonies of Vorticellid protozoa such as *Epistylis*.*

Of animals living in more or less intimate relations with the

* Further particulars regarding the life-history of this larva will be found on pp. 114 and 115, J. Asiat. Soc. Bengal, ii (n. s.) 1906.

polyp, I have found two very distinct species of protozoa, neither of which is identical with either of the two commonly found in association with *Hydra* in Europe, *Trichodina pediculus* and *Kerona polyporum* On two occasions, one in January and the other at the beginning of February, I have seen a minute colourless flagellate on the tentacles of the Calcutta polyp On the first occasion the tentacles were completely covered with this protozoon, so that they appeared at first sight as though encased in flagellated epithelium The minute organism was colourless, transparent, considerably larger than the spermatozoa of *Hydra*, slightly constricted in the middle and rounded at each end It bore a long flagellum at the end furthest from its point of attachment, the method of which I could not ascertain. When separated from the polyp little groups clung together in rosettes and gyrated in the water. On the other occasion only a few individuals were observed Possibly this flagellate was a parasite rather than a commensal, as the individual on which it swarmed was unusually emaciated and colourless, and bore neither gonads nor buds The larger stinging cells were completely covered by groups of the organism, and possibly this may have interfered with the discharge of stinging threads

The other protozoon was *Vorticella monilata*, Tatem, which has been found, not in association with *Hydra*, in Europe and S America. In Calcutta I have only seen it attached to the column of the polyp, but probably it would also be found, if carefully looked for, attached to water-weeds

Especially in the four-rayed stage, the polyp not infrequently attaches itself to shells of *Vivipara*, and, more rarely, to those of other molluscs It is doubtful whether this temporary association between *Hydra* and the mollusc is of any importance to the latter Even when the polyp settles on its body and not on its shell (as is sometimes the case) the *Vivipara* appears to suffer no inconvenience, and makes no attempt to get rid of its burden. It is possible, on the other hand, that the *Hydra* may protect it by devouring would-be parasites, but of this there is no evidence *

The association, however, is undoubtedly useful to *Hydra* The mud on the shells of *Vivipara* taken on floating objects shows

* In the Calcutta tanks operculate molluscs such as *Vivipara* are certainly more free from visible attack than non-operculate species This is the case, for instance, as regards the common aquatic glowworm (*Luciola* sp), which destroys large numbers of individuals of *Limnophysa*, *Limnæus*, &c If it has been starved for several days in an aquarium it will attack an operculate form, but rarely with success Similarly *Chætogaster bengalensis* attaches itself exclusively to non-operculate forms In the one case the polyp could do very little against an adversary with so stout an integument as the insect, while, in the other, it is doubtful whether the worm does any harm to its host The polyp would afford very little protection against the snail's vertebrate enemies or against what appears to be its chief foe, namely, drought As the water sinks in the tank non-operculate species migrate to the deeper parts, but *Vivipara* and *Ampullaria* close their shells, remain where they are, and so often perish, being left high and dry, exposed to the heat of the sun

that in cool weather the snail comes up from the bottom to the surface, and it probably goes in the opposite direction in hot weather Moreover, the common Calcutta species (*V. bengalensis*) feeds very largely, if not exclusively, on minute green algæ It therefore naturally moves towards spots where smaller forms of animal and vegetable life abound and conditions are favourable for the polyp The polyp's means of progression are limited, and the use of a beast of burden is most advantageous to it, for it can detach itself when it arrives at a favourable habitat If specimens are kept in water which is allowed to become foul, a very large proportion of them will attach themselves to any snails confined with them. Under natural conditions they would thus in all probability be rapidly conveyed to a more suitable environment In the tanks it is far commoner to find young four-rayed polyps on *Vivipara* than individuals with five or six rays. but the adults of the species are far less prone to change their position than are the young.

The Calcutta *Hydra*, especially in spring, exhibits a distinct tendency to frequent the neighbourhood of sponges and polyzoa, such as *Spongilla carteri* and the denser forms of *Plumatella*. Possibly this is owing to the shade these organisms provide

25 **Hydra oligactis**, *Pallas*

Polypes de la troisième espèce, Trembley, Mém hist Polypes,* pl i, figs 3, 4, 6, pl ii, figs 1–4, pl iii, fig 11, pl v, figs 1–4, pl vi, figs 3–7, 9, 10, pl viii, figs 8, 11, pl ix (1744)
Rösel von Rosenhof, Insekt-Belustigung, iii, Hist Polyp., pls lxxxiv–lxxxvi (1755)
Hydra socialis, Linné, Fauna Suecica, p 542 (1761)
Hydra oligactis, Pallas, Elench Zooph p 29 (1766)
? *Hydra attenuata*, *id*, *ibid* p 32
Hydra fusca, Linné, Syst Nat (ed 13), p 3870 (1782)
Hydra oligactis, Johnston, Brit Zooph i, p 124, fig 27 (p 120) (1847)
Hydra oligactis, Hincks, Hist Brit Hydr Zooph i, p 315, fig 42 (1868)
Hydra roeselii, Haacke, Jena Zeitschr Naturwiss xiv, p 135 (1880)
? *Hydra rhætica*, Asper, Zool Anz 1880, p 204, figs 1–3
Hydra vulgaris, Jickeli (*nec* Pallas), Morph Jahrb viii, p 391, pl xviii, fig 3 (1882)
Hydra fusca, Nussbaum, Arch. mikr Anat Bonn, xxix, p 273, pl xiv, figs 34–36, pl xv, figs 48–51, &c (1887)
Hydra fusca, Brauer, Zeit wiss Zool Leipzig, lii, p 177, pl xi, figs 2, 5, 6, pl xii, fig 6 (1891)
Hydra sp ? *id*, *ibid* pl xi, figs 3, 3 *a*, 4, 7, 8, pl xii, figs 1, 2, 5–13
Hydra fusca, Chun in Bronn's Thier-Reichs, ii (2), pl ii, figs 2 (*a*), 4, 6 (1892)
Hydra monœcia, Downing, Science * (5) xii, p 228
Hydra fusca, *id*, Zool Jahrb (Anat) xxi, p 382 (1905)
Hydra diœcia, *id*, *ibid* pl xxiii, figs 6, 7, &c
Hydra fusca, Hertwig, Biol Centralbl xxvi, p 489 (1906)

Hydra oligactis, Brauer, Zool. Anz xxxiii, p. 792, fig 2 (1908)
Hydra polypus, id, ibid
Hydra fusca, Frischholz, Ann Zool (Wurzburg), iii, p 114, figs 2-9 (1909)
Hydra oligactis, Brauer, Susswasserfauna Deutschl xix, p 193, figs 339-341 (1909)
Hydra polypus, id, ibid figs 342-344

This species differs from *H. vulgaris* in the following characters —

(1) Even when the gastral cavity is empty, the basal part of the column is distinctly more slender than the upper part,
(2) even when the animal is at rest, the tentacles are much longer than the column,
(3) the nettle-cells of both types are usually smaller and more uniform in size than in the other species, those with barbed threads (fig. 27, p 131) are always flask-shaped and somewhat narrower in proportion to their length, while those with simple threads are pointed or almost pointed at their distal end,
(4) the stinging threads of the more complex form are comparatively stout and short,
(5) there are comparatively few nettle-cells in the column;
(6) the egg-shell is nearly smooth or covered more or less completely with short, simple spines (fig 28, p 137).

H oligactis is usually a more vigorous form than *H vulgaris* and, in spite of its name, has often a considerable number of tentacles The few Indian specimens examined have, however been small and have not had more than six tentacles I have not seen an Indian specimen with more than two buds, but European specimens sometimes produce a great many, and as the daughter buds do not always separate from the parent until they have themselves produced buds, temporary colonies of some complexity arise, Chun figures a specimen with nineteen daughter and granddaughter buds *

In Europe and N America there appear to be two races or phases of the species To avoid ambiguity they may be called form A and form B and described as follows :—

Form A is of vigorous growth. It is as a rule diœcious, and its reproductive organs may be borne practically at any level on the surface of the column Its eggs are spherical and as a rule covered almost uniformly with spines

* Pallas writes as regards this "pulcherrime vegetantem varietatem" with his usual critical insight, "Vix tamen peculiaris speciei nomine salutanda videtur" It is probably the *Hydra socialis* of Linné

Form B is smaller and has smaller and more variable nettle-cells Its reproductive organs are borne only on the distal third or at the base of its column and it is often monœcious The lower surface of its egg is flattened, adherent, and devoid of spines

The larger form (*A*) was originally named *Hydra monœcia* by Downing, who in 1904 expressed a wish to substitute for the specific name, which had been given through inadvertence, the more appropriate one *diœcia* As, however, it appears to be the commoner of the two in northern Europe, we may regard it as probably being the one named *Hydra oligactis* by Pallas and therefore may accept it as the *forma typica* of that species According to Brauer (1908) the smaller form is Linné's *Hydra polypus*, but the original description of the "species" hardly bears out this view As reproductive organs have not yet been found in Indian specimens, it is impossible to say to which of the two forms they belong

A red form of *H oligactis* occurs in Tibet in the lake Rham-tso, at an altitude of about 15,000 feet and has been reported from various small lakes in mountainous parts of Europe It is probably the form called *Hydra rhœtica* by Asper, but his figures are lacking in detail and appear to have been drawn from specimens in a state of partial contraction *H rubra*, Lewes (Ann Mag. Nat Hist (3) v, p 71, 1860), may also be identical with this form Roux, indeed, states that *H. rubra* is only found living unattached at considerable depths (Ann Biol lacustre ii, p 266, 1907); but this statement does not accord with the fact that Lewes's specimens were found in ponds on Wimbledon Common

Type not in existence

Geographical Distribution —*H oligactis* is widely distributed in Europe and N America, but in India has only been found in and near the city of Lahore in the Punjab

Biology —This species was found by Major J Stephenson, I M S, in the basin of a fountain at Lahore and in an ornamental canal in the Shalimar Gardens on the outskirts of the same city. Nothing is known as regards its habits in this country. In N America, according to Downing, form B breeds in September and October and form A from October to December The eggs of form B remain attached to the parent until the two cellular layers are formed and then drop off, whereas those of form A are fixed by the parent to some extraneous object, its column contracting until they are in a favourable position for attachment

The colour of Indian examples of *H oligactis* apparently resembles that of the Calcutta winter brood of *H. vulgaris* so far as visual effect is concerned, but I have noticed in specimens from Lahore and the neighbourhood that very minute spherical bodies of a dark green colour are present in the endoderm cells

PART III.

FRESHWATER POLYZOA

(CTENOSTOMATA & PHYLACTOLÆMATA).

INTRODUCTION TO PART III.

I.

Status and Structure of the Polyzoa.

The Polyzoa constitute a class in the third great division of the animal kingdom, the so-called Triploblastea. In this division are included also the worms, molluscs, insects, crustacea, spiders, vertebrates, etc.; for heterogeneous as its elements appear, all these animals may be considered to have essential features in common, in particular a body consisting primarily of three cellular layers Most of them also possess a body cavity distinct from the alimentary canal. Some authors regard the position of the polyzoa as near that of the higher worms, but the group is an isolated one.

In considering the anatomy of simple forms of animal life such as the sponges it is necessary to pay attention mainly to individual cells, but in discussing more complicated forms our notice is first attracted to tissues and organs, for the cells of which these tissues and organs are composed have each a definite position, a definite structure, and a definite function. The most characteristic feature of the polyzoa, considered from this point of view, is the fact that most of their organs fall into one of two categories and are connected either with what is called the "zoœcium" or with what is known as the "polypide" The zoœcium is a cage in which the polypide is enclosed, but it is a living cage, differing from the shell of a snail or the tubes in which many worms encase themselves in being part of the animal itself. The polypide consists mainly of the organs connected directly and indirectly with nutrition and of part of the muscular system; its name is derived from the fact that it bears a superficial resemblance to a polyp such as *Hydra*.

The shape and structure of the zoœcium differs greatly in different groups of polyzoa In its simplest form it is merely a cylindrical tube of living matter which secretes an outer horny or gelatinous covering It is open at the end furthest from its base, at which it is attached either to another zoœcium or to some kind of supporting structure. Certain parts of the polypide can always be extruded from the aperture, which is known technically as the "orifice," or withdrawn through it into the zoœcium.

When the polypide is retracted it draws in with it a portion of the zoœcium. The dead outer layer or ectocyst lines part of the portion thus invaginated and forms the walls of a cavity within the orifice The base of this cavity consists in many forms of a transverse partition pierced in the middle by a circular hole and known as the "diaphragm." The diaphragm, however, does not constitute the limit of the invaginated portion of the zoœcium, for the living inner wall or endocyst is dragged in still further and forms a sheath round the retracted tentacles When the tentacles are protruded they emerge through the hole in the diaphragm, carrying with them their sheath of endocyst The invagination above the diaphragm, consisting of both endocyst and ectocyst, is then everted

The tentacles are a characteristic feature of the polypide Together with the base to which they are attached they are known as the "lophophore", they surround the mouth, usually in a circle They differ widely from the tentacles of *Hydra* in both structure and function, although they too serve as organs for the capture of prey; they are not highly contractile and are not provided with nettle-cells but are covered with cilia, which are in constant motion When extruded they form a conspicuous calix-like crown to the zoœcium, but in the retracted condition they are closely pressed together and lie parallel to one another. They are capable individually of motion in all directions but, although they usually move in concert, they cannot as a rule seize objects between them.

The mouth is a hole situated in the midst of the tentacles It leads directly into a funnel-shaped œsophagus, the upper part of which is lined with cilia and is sometimes distinguished as the "pharynx,' while the lower part, the œsophagus proper, is a thin-walled tube that connects the pharynx with the stomach, which it enters on the dorsal side The stomach is a bulky organ that differs markedly in form and structure in different groups of polyzoa It is lined internally with glandular cells and the inner wall is sometimes thrown into folds or "rugæ" The part with which the œsophagus communicates is known as the "cardiac" portion, while the part whence the intestine originates is called the "pylorus" or "pyloric" portion. The intestine commences on the ventral side opposite the entrance of the œsophagus and nearly on a level with it, the bulk of the stomach depending between the two tubes This part of the stomach is often produced into a blind tube, the fundus or cæcum The alimentary canal may therefore be described as distinctly Y-shaped The proximal part of the intestine is in some forms lined with cilia, and the tube as a whole is usually divided into two parts—the intestine proper, which is nearest the stomach, and the rectum, which opens by the anus not far from the mouth

The nervous system consists of a central ganglion or brain, which is situated at the base of the tentacles on the side nearest the anus and gives out radiating nerves in all directions Close

to the brain and providing a communication between the cavity of the zoœcium and the cavity in which the tentacles are contained (or, in the case of an expanded polyp, the external world) is a ciliated tube known as the "intertentacular organ" Apparently it acts as a passage through which the genital products are

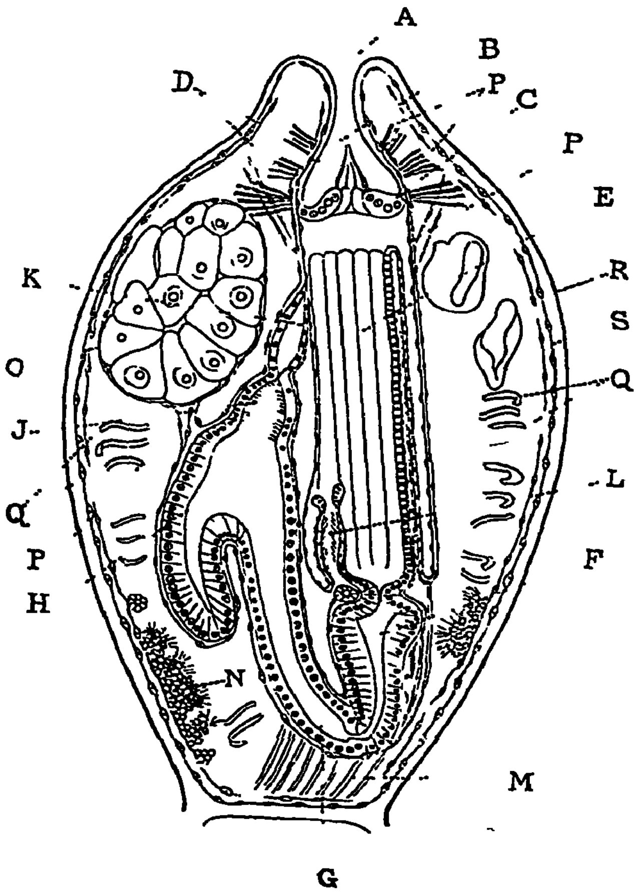

Fig 30—Vertical section through a polypide of *Alcyonidium* with the polypide retracted (after Prouho)

A = orifice, B = contracted collar, C = diaphragm, D = parieto-vaginal muscles, E = tentacles, F = pharynx, G = œsophagus, H = stomach, J = intestine, K = rectum, L = intertentacular organ, M = retractor muscle, N = testes, O = ovary, P=funiculus, Q = parietal muscles, R = ectocyst, S = endocyst

expelled, but contradictory statements have been made regarding it, and perhaps it is present only at certain seasons or in certain conditions of the polypide

The muscular system is often of a complicated nature, but three sets of muscles may be distinguished as being of peculiar importance, viz, (1) the retractor muscles, which are fixed to the

base of the lophophore at one end and to the base of the zoœcium at the other, and by contracting pull the former back into the zoœcium; (ii) the parieto-vaginal muscles, which connect the upper part of the invaginated portion of the zoœcium with the main wall thereof, and (iii) the parietal muscles, which run round the inner wall of the zoœcium and compress the zoœcium as a whole The parietal muscles are not developed in the Phylactolæmata, the most highly specialized group of freshwater polyzoa.

The cavity between the polypide and the zoœcium contains a reticulate tissue of cells known as the "funicular" tissue, and this tissue is usually concentrated to form a hollow strand or strands ("funiculi") that connect the outer wall of the alimentary canal with the endocyst

This rapid sketch of the general anatomy of a simple polyzoon will be the best understood by comparing it with fig 30, which represents, in a somewhat diagrammatic fashion, a vertical section through a single zoœcium and polypide of the order Ctenostomata, to which some of the freshwater species belong The polypide is represented in a retracted condition in which the Y-shaped disposition of the alimentary canal is somewhat obscured

In the great majority of cases the polyzoa form permanent colonies or polyparia, each of which consists of a number of individual zoœcia and polypides connected together by threads of living tissue These colonies are formed by budding, not by independent individuals becoming associated together. In a few cases compound colonies are formed owing to the fact that separate simple colonies congregate and secrete a common investment, but in these cases there is no organic connection between the constituent colonies. It is only in the small subclass Entoprocta, the polypides and zoœcia of which are not nearly so distinct from one another as they are in other polyzoa (the Ectoprocta), that mature solitary individuals occur

As representatives of both subclasses of polyzoa and of more than one order of Ectoprocta occur in fresh water, I have prefaced my description of the Indian species with a synopsis of the more conspicuous characters of the different groups (pp 183–186)

CAPTURE AND DIGESTION OF FOOD ELIMINATION OF WASTE PRODUCTS

The food of all polyzoa consists of minute living organisms, but its exact nature has been little studied as regards individual species and genera In *Victorella bengalensis* it consists largely of diatoms, while the species of *Hislopia* and *Arachnoidea* possess an alimentary canal modified for the purpose of retaining flagellate organisms until they become encysted Similar organisms form a large part of the food of the phylactolæmata

Although the tentacles may be correctly described as organs used in capturing prey, they do not themselves seize it but waft

it by means of the currents set up by their cilia to the mouth, into which it is swept by the currents produced by the cilia lining the pharynx The tentacles are also able in some species to interlace themselves in order to prevent the escape of prey. Apparently they have the power of rejecting unsuitable food, for they may often be observed to bend backwards and forwards and thrust particles that have approached them away, and if the water contains anything of a noxious nature in solution the lophophore is immediately retracted, unless it has been completely paralysed In the phylactolæmata the peculiar organ known as the epistome is capable of closing the mouth completely, and probably acts as an additional safeguard in preventing the ingestion of anything of an injurious nature.

In many genera and larger groups the food commonly passes down the pharynx into the stomach without interruption, although it is probable that in all species the œsophagus can be closed off from the stomach by a valve at its base In some forms, however, a "gizzard" is interposed between the œsophagus and the stomach. This gizzard has not the same function in all cases, for whereas in some forms (*e g*, in *Bowerbankia*) it is lined with horny projections and is a powerful crushing organ, in others (*e. g*, in *Hislopia* or *Victorella*) it acts as an antechamber in which food can be preserved without being crushed until it is required for digestion, or rough indigestible particles can be retained which would injure the delicate walls of the stomach

Digestion takes place mainly in the stomach, the walls of which are of a glandular nature The excreta are formed into oval masses in the rectum and are extruded from the anus in this condition

Although the gross non-nutritious parts of the food are passed *per anum*, the waste products of the vital processes are not eliminated so easily, and a remarkable process known as the formation of brown bodies frequently takes place. This process cannot be described more clearly and succinctly than by quoting Dr. Harmer's description of it from pp 471 and 472 of vol ii of the Cambridge Natural History, a volume to which I have been much indebted in the preparation of this introduction The description is based very largely on Dr. Harmer's own observations *

"The tentacles, alimentary canal, and nervous system break down, and the tentacles cease to be capable of being protruded The degenerating organs become compacted into a rounded mass, known from its colour as the 'brown body' This structure may readily be seen in a large proportion of the zoœcia of transparent species In active parts of the colony of the body-wall next develops an internal bud-like structure, which rapidly acquires the form of a new polypide This takes the place originally occupied by the

* Q J Micr Sci xxxiii, p 123 (1892)

old polypide, while the latter may either remain in the zoœcium in the permanent form of a 'brown body,' or pass to the exterior. In *Flustra* the young polypide-bud becomes connected with the 'brown body' by a funiculus. The apex of the blind pouch or 'cæcum' of the young stomach is guided by this strand to the 'brown body,' which it partially surrounds The 'brown body' then breaks up, and its fragments pass into the cavity of the stomach, from which they reach the exterior by means of the anus."

Brown bodies are rarely if ever found in the phylactolæmata, in which the life of the colony is always short; but they are not uncommon in *Hislopia* and *Victorella*, although in the case of the former they may easily escape notice on account of the fact that they are much paler in colour than is usually the case When they are found in a ctenostome the collar-like membrane characteristic of the suborder is extruded from the orifice (which then disappears) and remains as a conspicuous external addition to the zoœcium, the ectocyst of which, at any rate in *Bowerbankia* and *Victorella*, sometimes becomes thickened and dark in colour.

It is noteworthy that the colouring matter of the brown bodies is practically the only colouring matter found in the polypides of most polyzoa. Young polypides are practically colourless in almost all cases.

REPRODUCTION · BUDDING.

Polyzoa reproduce their species in three ways—(i) by means of eggs, (ii) by budding, and (iii) by means of bodies developed asexually and capable of lying dormant in unfavourable conditions without losing their vitality.

Most, if not all species are hermaphrodite, eggs and spermatozoa being produced either simultaneously or in succession by each individual, or by certain individuals in each zoarium. The reproductive organs are borne on the inner surface of the endocyst, as a rule in a definite position, and often in connection with the funiculus or funiculi. It is doubtful to what extent eggs are habitually fertilized by spermatozoa of the individual that has borne them, but in some cases this is practically impossible and spermatozoa from other individuals must be introduced into the zoœcium.

Budding as a rule does not result in the formation of independent organisms, but is rather comparable to the proliferation that has become the normal method of growth in sponges, except of course that individuality is much more marked in the component parts of a polyzoon colony than it is in a sponge. In the genera described in this volume budding takes place by the outgrowth of a part of the body-wall and the formation therein of a new polypide, but the order in which the buds appear and their arrangement in reference to the parent zoœcium is different in the

different groups In the freshwater ctenostomes three buds are typically produced from each zoœcium, one at the anterior end and one at either side, the two latter being exactly opposite one another. The parent zoœcium in this formation arises from another zoœcium situated immediately behind it, so that each zoœcium, except at the extremities of the zoarium, is connected with four other zoœcia, the five together forming a cross The two lateral buds are, however, frequently suppressed, or only one of them is developed, and a linear series of zoœcia with occasional lateral branches is formed instead of a series of crosses In the phylactolæmata, on the other hand, the linear method of budding is the typical one, but granddaughter-buds are produced long before the daughter-buds are mature, so that the zoœcia are frequently pressed together, and lateral buds are produced irregularly In *Victorella* additional adventitious buds are produced freely near the tip of the zoœcium

Reproduction by spontaneous fission sometimes occurs, especially in the Lophopinæ, but the process differs from that which takes place when a *Hydra* divides into two, for there is no division of individual zoœcia or polypides but merely one of the whole zoarium

The production of reproductive bodies analogous to the gemmules of sponges appears to be confined in the polyzoa to the species that inhabit fresh or brackish water, nor does it occur in all of these

All the phylactolæmata produce, within their zoœcia, the bodies known as statoblasts These bodies consist essentially of masses of cells containing abundant food-material and enclosed in a capsule with thick horny walls In many cases the capsule is surrounded by a "swim-ring" composed of a mass of horny-walled chambers filled with air, which renders the statoblast extremely light and enables it to float on the surface of the water, while in some genera the margin of the swim-ring bears peculiar hooked processes, the function of which is obscure The whole structure first becomes visible as a mass of cells (the origin of all of which is not the same) formed in connection with the funiculus, and the statoblast may be regarded as an internal bud Its origin and development in different genera has been studied by several authors, notably by Oka* in *Pectinatella*, and by Braem† in *Cristatella*

The external form of the statoblasts is very important in the classification of the phylactolæmata, to which these structures are confined In all the genera that occur in India they are flattened and have an oval, circular, or approximately oval outline

In temperate climates statoblasts are produced in great

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* Journ Coll Sci Tokyo, iv, p 124 (1891)
† Bibliotheca Zoologica, ii, pt 6, p 17 (1890)

profusion at the approach of winter, but in India they occur, in most species, in greatest numbers at the approach of the hot weather

In the family Paludicellidæ (ctenostomata) external buds which resemble the statoblasts in many respects are produced at the approach of unfavourable climatic conditions, but no such buds are known in the family Hislopiidæ, the zoaria of which appear to be practically perennial The buds consist of masses of cells formed at the points at which ordinary buds would naturally be produced, but packed with food-material and protected like statoblasts by a thick horny coat It seems also that old zoœcia and polypides are sometimes transformed into buds of the kind (fig 31), and it is possible that there is some connection between

Fig 31 —Part of the zoarium of *Victorella bengalensis* entirely transformed into resting buds, × 25 (From an aquarium in Calcutta)

the formation of brown bodies and their production Like the statoblasts of the phylactolæmata the resting buds of the Paludicellidæ are produced in Europe at the approach of winter, and in India at that of the hot weather.

DEVELOPMENT

(a) *From the Egg.*

Some polyzoa are oviparous, while in others a larva is formed within the zoœcium and does not escape until it has attained some complexity of structure Both the ctenostomatous genera that are found in fresh water in India are oviparous, but whereas in *Victorella* the egg is small and appears to be extruded soon after its fertilization, in *Hislopia* it remains in the zoœcium for a considerable time, increases to a relatively large size, and in some unknown manner accumulates a considerable amount of food-material before escaping Unfortunately the development is unknown in both genera

In the phylactolæmata the life-history is much better known, having been studied by several authors, notably by Allman, by Kraepelin, and by Braem (1908) The egg is contained in a thin

membrane, and while still enclosed in the zoœcium, forms by regular division a hollow sphere composed of similar cells This sphere then assumes an ovoid form, becomes covered with cilia externally, and breaks its way through the egg-membrane into the cavity of the zoœcium Inside the embryo, by a process analogous to budding, a polypide or a pair of polypides is formed Meanwhile the embryo has become distinctly pear-shaped, the polypide or polypides being situated at its narrow end, in which a pore makes its appearance The walls are hollow in the region occupied by the polypide, the cavity contained in them being bridged by slender threads of tissue The larva thus composed makes its way out of the zoœcium, according to Kraepelin through the orifice of a degenerate bud formed for its reception, and swims about for a short time by means of the cilia with which it is covered Its broad end then affixes itself to some solid object, the polypide is everted through the pore at the narrow end and the whole of that part of the larva which formerly enclosed it is turned completely inside out A zoarium with its included polypides is finally produced from the young polypide by the rapid development of buds

(b) *From the Statoblast and Resting Buds.*

There is little information available as regards the development of the young polyzoon in the resting buds of the freshwater ctenostomes In *Paludicella* and *Pottsiella* the capsule of the bud splits longitudinally into two valves and the polypide emerges between them ; but in *Victorella bengalensis* one of the projections on the margin of the bud appears to be transformed directly into the tip of a new zoœcium and the capsule is gradually absorbed

Contradictory statements have been made as regards several important points in the development of the statoblast and it is probable that considerable differences exist in different species The following facts appear to be of general application. The cellular contents of the capsule consist mainly of a mass of cells packed with food-material in a granular form, the whole enclosed in a delicate membrane formed of flat cells When conditions become favourable for development a cavity appears near one end of the mass and the cells that form its walls assume a columnar form in vertical section The cavity increases rapidly in size, and, as it does so, a young polypide is budded off from its walls Another bud may then appear in a similar fashion, and the zoœcium of the first bud assumes its characteristic features The capsule then splits longitudinally into two disk-like valves and the young polypide, in some cases already possessing a daughter bud, emerges in its zoœcium, adheres by its base to some external object and produces a new polyparium by budding The two valves of the statoblast often remain attached to the zoarium that has emerged from between them until it attains considerable dimensions (see Plate IV, fig 3 *a*)

What conditions favour development is a question that cannot yet be answered in a satisfactory manner Statoblasts can lie dormant for months and even for years without losing their power of germinating, and it is known that in Europe they germinate more readily after being subjected to a low temperature In tropical India this is, of course, an impossible condition, but perhaps an abnormally high temperature has the same effect. At any rate it is an established fact that whereas the gemmules of most species germinate in Europe in spring, in Bengal they germinate either at the beginning of the "rains" or at that of our mild Indian winter

Movements

In the vast majority of the polyzoa, marine as well as freshwater, movement is practically confined to the polypide, the external walls of the zoœcium being rigid, the zoœcia being closely linked together and the whole zoarium permanently fixed to some extraneous object. In a few freshwater species belonging to the genera *Cristatella*, *Lophopus*, *Lophopodella* and *Pectinatella*, the whole zoarium has the power of progression This power is best developed in *Cristatella*, which glides along with considerable rapidity on a highly specialized "sole" provided with abundant mucus and representing all that remains of the ectocyst It is by no means clear how the zoaria of the other genera move from one place to another, for the base is not modified, so far as can

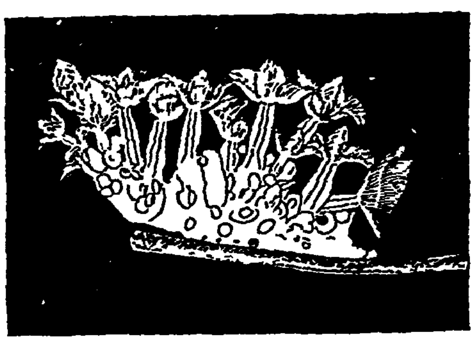

Fig 32.—Zoarium of *Lophopodella carteri* moving along the stem of a water plant, × 4 (From Igatpuri Lake)

be seen, for the purpose, and the motion is extremely slow It is probable, however, that progression is effected by alternate expansions and contractions of the base, and in *Lophopodella* (fig 32), which moves rather less slowly than its allies, the anterior part of the base is raised at times from the surface along which it is moving. The whole zoarium can be released in this way and occasionally drops through the water, and is perhaps carried by currents from one place to another in so doing.

So far as the polypides are concerned, the most important movements are those which enable the lophophore and the adjacent parts to be extruded from and withdrawn into the zooecium. The latter movement is executed by means of the retractor muscles, which by contracting drag the extruded parts back towards the posterior end of the endocyst, but it is not by any means certain how the extrusion of the lophophore is brought about. In most ctenostomes the action of the parietal muscles doubtless assists in squeezing it out when the retractor and parieto-vaginal muscles relax, but Oka states that protrusion can be effected in the phylactolæmata even after the zooecium has been cut open Possibly some hydrostatic action takes place, however, and allowance must always be made for the natural resilience of the inverted portion of the ectocyst.

Even when the polypide is retracted, muscular action does not cease, for frequent movements, in some cases apparently rhythmical, of the alimentary canal may be observed, and in *Hislopia* contraction of the gizzard takes place at irregular intervals.

When the lophophore is expanded, the tentacles in favourable circumstances remain almost still, except for the movements of their cilia, but if a particle of matter too large for the mouth to swallow or otherwise unsuitable is brought by the currents of the cilia towards it, individual tentacles can be bent down to wave it away and similar movements are often observed without apparent cause

In the cheilostomes certain individuals of each zoarium are often profoundly modified in shape and function and exhibit almost constant rhythmical or convulsive movements, some ("avicularia") being shaped like a bird's beak and snapping together, others ("vibracula") being more or less thread-like and having a waving motion

Distribution of the Freshwater Polyzoa

Fifteen genera of freshwater Polyzoa are now recognized, one entoproctous and fourteen ectoproctous, five of the latter are ctenostomatous and nine phylactolæmatous Of the fourteen ectoproctous genera seven are known to occur in India, viz, *Victorella*, *Hislopia*, *Fredericella*, *Plumatella*, *Stolella*, *Lophopodella*, and *Pectinatella* Except *Stolella*, which is only known from northern India, these genera have an extremely wide geographical range, *Victorella* occurs in Europe, India, Africa, and Australia, *Hislopia* in India, Indo-China, China, and Siberia, *Fredericella* in Europe, N America, Africa, India, and Australia, *Plumatella* in all geographical regions, *Lophopodella* in E and S Africa, India, and Japan, *Pectinatella* in Europe, N America, Japan, and India

Two genera, *Paludicella* and *Lophopus*, have been stated on insufficient grounds to occur in India. The former is known

from Europe and N America, and is said to have been found in Australia, while the latter is common in Europe and N America and also occurs in Brazil

Of the genera that have not been found in this country the most remarkable are *Urnatella* and *Cristatella* The former is the only representative in fresh water of the Entoprocta and has only been found in N America Each individual is borne upon a segmented stalk the segments of which are enclosed in strong horny coverings and are believed to act as resting buds. *Cristatella*, which is common in Europe and N. America, is a phylactolæmatous genus of highly specialized structure It possesses a creeping "sole" or organ of progression at the base of the zoarium

The other phylactolæmatous genera that do not occur in India appear to be of limited distribution, for *Australella* is only known from N S Wales, and *Stephanella* from Japan The ctenostomatous *Arachnoidea* has only been reported from Lake Tanganyika, and *Pottsiella* only from a single locality in N America.

As regards the exotic distribution of the Indian species little need be said The majority of the *Plumatellæ* are identical with European species, while the only species of *Fredericella* that has been discovered is closely allied to the European one The Indian species of *Lophopodella* occurs also in E Africa and Japan, while that of *Pectinatella* is apparently confined to India, Burma and Ceylon, but is closely allied to a Japanese form

Polyzoa of Brackish Water

With the exception of *Victorella*, which occurs more commonly in brackish than in fresh water and has been found in the sea, the genera that occur in fresh water are confined or practically confined to that medium, but certain marine ctenostomes and cheilostomes not uncommonly make their way, both in Europe and in India, into brackish water, and in the delta of the Ganges an entoproctous genus also does so The ctenostomatous genera that are found occasionally in brackish water belong to two divisions of the suborder, the Vesicularina and the Alcyonellea. To the former division belongs *Bowerbankia*, a form of which (*B caudata* subsp *bengalensis*, p 187) is often found in the Ganges delta with *Victorella bengalensis* No species of Alcyonellea has, however, as yet been found in Indian brackish waters The two Indian cheilostomes of brackish water belong to a genus (*Membranipora*) also found in similar situations in Europe One of them (*M. lacroixii* *) is, indeed, identical with a European form

* There is some doubt as to the proper name of this species, which may not be the one originally described as *Membranipora lacroixii* by Audouin I follow Busk and Hincks in my identification (see Cat Polyzoa Brit Mus ii, p 60, and Hist Brit Polyzoa, p 129) Levinsen calls it *M hippopus*, sp nov (see Morphological and Systematic Studies on the Cheilostomatous Bryozoa, p 144, Copenhagen, 1909)

that occurs in England both in the sea and in ditches of brackish water. I have found it in the Cochin backwaters, in ponds of brackish water at the south end of the Chilka Lake (Ganjam, Madras), on the shore at Puri in Orissa, and in the Mutlah River at Port Canning The second species (*M bengalensis*, Stoliczka) is peculiar to the delta of the Ganges* and has not as yet been found in the open sea The two species are easily recognized from one another, for whereas the lip of *M bengalensis* (fig 33)

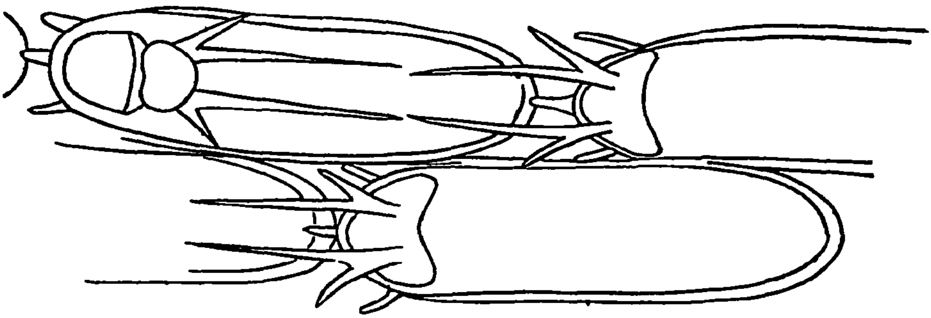

Fig 33 —Outline of four zooecia of *Membranipora bengalensis*, Stoliczka (from type specimen, after Thornely) In the left upper zooecium the lip is shown open

bears a pair of long forked spines, there are no such structures on that of *M lacroixii*, the dorsal surface of which is remarkably transparent *M lacroixii* forms a flat zoarium, the only part visible to the naked eye being often the beaded margin of the zooecia, which appears as a delicate reticulation on bricks, logs of wood, the stems of rushes and of hydroids, etc , but the zoarium of *M bengalensis* is as a rule distinctly foliaceous and has a peculiar silvery lustre.

Loxosomatoides † (fig. 34), the Indian entoproctous genus found in brackish water, has not as yet been obtained from the open sea, but has recently been introduced, apparently from a tidal creek, into isolated ponds of brackish water at Port Canning It is easily recognized by the chitinous shield attached to the ventral (posterior) surface

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* Miss Thornely (Rec Ind Mus i, p 186, 1907) records it from Mergui, but this is an error due to an almost illegible label The specimens she examined were the types of the species from Port Canning Since this was written I have obtained specimens from Bombay—*April*, 1911

† Annandale, Rec Ind Mus ii, p 14 (1908).

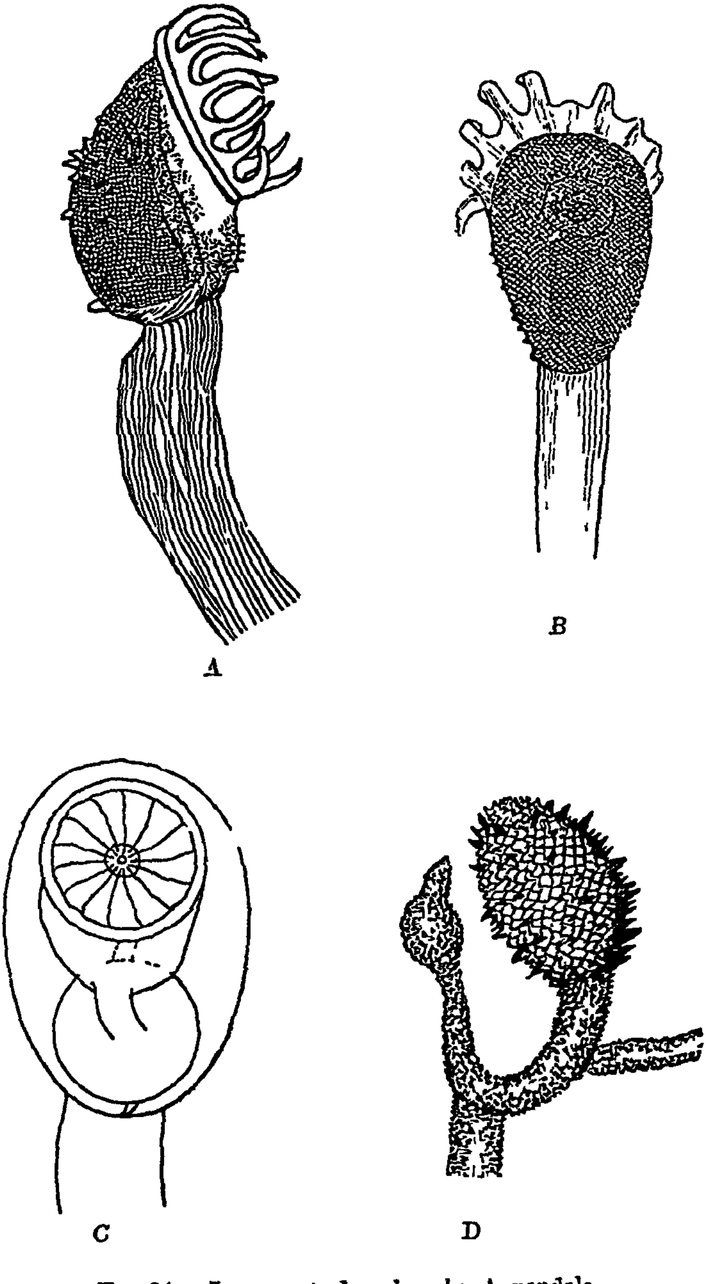

Fig 34 —*Loxosomatoides colonialis*, Annandale

A and B, a single individual of form A, as seen (A) in lateral, and (B) in ventral view, C, outline of a similar individual with the tentacles retracted, as seen from in front (dorsal view), D, ventral view of an individual and bud of form B. All the figures are from the type specimens and are multiplied by about 70

II.

History of the Study of the Freshwater Polyzoa.

The naturalists of the eighteenth century were acquainted with more than one species of freshwater polyzoon, but they did not distinguish these species from the hydroids Trembley discovered *Cristatella*, which he called "Polype à Panache," in 1741, and Linne described a species of *Plumatella* under the name *Tubipora repens* in 1758, while ten years later Pallas gave a much fuller description (under the name *Tubularia fungosa*) of the form now known as *Plumatella fungosa* or *P repens* var *fungosa*. Although Trembley, Baker, and other early writers on the fauna of fresh water published valuable biological notes, the first really important work of a comprehensive nature was that of Dumortier and van Beneden, published in 1848 All previous memoirs were, however, superseded by Allman's Monograph of the Fresh-Water Polyzoa, which was issued in 1857, and this memoir remains in certain respects the most satisfactory that has yet been produced In 1885 Jullien published a revision of the phylactolæmata and freshwater ctenostomes which is unfortunately vitiated by some curious lapses in observation, but it is to Jullien that the recognition of the proper position of *Hislopia* is due The next comprehensive monograph was that of Kraepelin, which appeared in two parts (1887 and 1892) in the Abhandlungen des Naturwiss Vereins of Hamburg In its detailed information and carefully executed histological plates this work is superior to any that preceded it or has since appeared, but the system of classification adopted is perhaps less liable to criticism than that followed by Braem in his "Untersuchungen," published in the Bibliotheca Zoologica in 1888

During the second half of the nineteenth century and the first decade of the twentieth several authors wrote important works on the embryology and anatomy of the phylactolæmata, notably Kraepelin, Braem, and Oka, but as yet the ctenostomes of fresh water have received comparatively little attention from anything but a systematic point of view.

From all points of view both the phylactolæmata and the ctenostomes of Asia have been generally neglected, except in the case of the Japanese phylactolæmata, which have been studied by Oka Although Carter made some important discoveries as regards the Indian forms, he did not devote to them the same attention as he did to the sponges In the case of the only new genus he described he introduced a serious error into the study of the two groups by placing *Hislopia* among the cheilostomes, instead of in its true position as the type genus of a highly specialized family of ctenostomes.

For fuller details as to the history of the study of the freshwater Polyzoa the student may refer to Allman's and to Kraepelin's monographs An excellent summary is given by Harmer in his

chapter on the freshwater Polyzoa in vol ii of the Cambridge Natural History, and Loppens has recently (1908) published in the Annales de Biologie lacustre a concise survey of the systematic work that has recently been undertaken Unfortunately he perpetuates Carter's error as regards the position of *Hislopia*

BIBLIOGRAPHY OF THE FRESHWATER POLYZOA

A very full bibliography of the freshwater Polyzoa will be found in pt i of Kraepelin's "Die Deutschen Susswasserbryozoen" (1887), while Loppens, in his survey of the known species (Ann Biol lacustre, ii, 1908), gives some recent references The following list contains the titles of some of the more important works of reference, of memoirs on special points such as reproduction and of papers that have a special reference to Asiatic species Only the last section is in any way complete.

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1856 ALLMAN, "A Monograph of the Fresh-Water Polyzoa" (London)

1866–1868 HYATT, "Observations on Polyzoa, suborder Phylactolæmata," Comm Essex Inst iv, p 197, v, p 97

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1885 JULLIEN, "Monographie des Bryozoaires d'eau douce," Bull Soc zool France, x, p 91

1887 & 1892 KRAEPELIN, "Die deutschen Susswasserbryozoen," Abhandl Nat Vereins Hamburg, x & xii

1890 BRAEM, "Untersuchungen des Bryozoen des sussen Wassers," Bibl Zool ii, Heft 6 (Cassel)

1896 HARMER, Cambridge Natural History, ii, Polyzoa, chap xviii

1899 KORSCHELT and HEIDER, "Embryology of Invertebrates," vol ii, chap xvi (English edition by Bernard and Woodward, 1899)

1908 LOPPENS, "Les Bryozoaires d'eau douce," Ann Biol lacustre, iii, p 141

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1875 NITSCHE, "Beitrage zur Kenntniss der Bryozoen," Zeitschr f wiss Zool xxv (supplement), p 343

1880 REINHARD, "Zur Kenntniss der Susswasser-Bryozoen," Zool Anz iii, p 208

1888 BRAEM, "Untersuchungen uber die Bryozoen des sussen Wassers," Zool Anz xi, pp 503, 533.

1891 OKA, "Observations on Freshwater Polyzoa," J Coll Sci Tokyo, iv, p 89

1906 WILCOX, "Locomotion in young colonies of *Pectinatella magnifica*," Biol Bull Wood's Holl, ii

1908 BRAEM, "Die geschlechtliche Entwickelung von *Fredericella sultana* nebst Beobachtungen uber die weitere Lebensgeschichte der Kolonien," Bibl Zool xx, Heft 52

(c) *Papers that refer specifically to Asiatic species*

1851 LEIDY described *Plumatella diffusa* in Proc Ac Philad v, p 261 (1852)

1858 CARTER, "Description of a Lacustrine Bryozoon allied to *Flustra*," Ann Nat Hist (3) i, p 169

1859 CARTER, "On the Identity in Structure and Composition of the so-called Seed-like Body of *Spongilla* with the Winter-egg of the Bryozoa and the presence of Starch-granules in each," Ann Nat Hist (3) iii, p 331 (Statoblast of *Lophopodella* described and figured)

1862 MITCHELL, "Freshwater Polyzoa," Q J Micr Sci (new series) ii, p 61 ("*Lophopus*" recorded from Madras)

1866 HYATT, "Observations on Polyzoa, suborder Phylactolæmata," Comm Essex Inst iv, p 197 ("*Pectinatella carteri*" named)

1869 STOLICZKA, "On the Anatomy of *Sagartia schilleriana* and *Membranipora bengalensis*, a new coral and a bryozoon living in brackish water at Port Canning," J As Soc Bengal, xxxviii, ii, p 28

1880 JULLIEN, "Description d'un nouveau genre de Bryozoaire Cheilostomien des eaux douces de la Chine et du Cambodge et de deux espèces nouvelles," Bull Soc zool France, v, p 77 ("*Norodonia*" described)

1885 JULLIEN, "Monographie des Bryozoaires d'eau douce," Bull Soc zool France, x, p 91 (*Hislopia* assigned to the ctenostomes)

1887 KRAEPELIN, "Die deutschen Susswasserbryozoen," Abh Ver Hamburg, x (*Plumatella philippinensis*)

1891 OKA, "Observations on Freshwater Polyzoa," J Coll Sci Tokyo, iv, p 89

1898 MEISSNER, "Die Moosthiere Ost-Afrikas," in Mobius's Deutsch-Ost-Afrika, iv (*Lophopodella carteri* recorded from E Africa)

1901 KOROTNEFF, "Faunistische Studien am Baikalsee," Biol Centrbl xxi, p 305 ("*Echinella*" described)

1904–1906 ROUSSELET, "On a new Freshwater Polyzoon from Rhodesia, *Lophopodella thomasi*, gen et sp nov ", J Quekett Club (2) ix, p 45 (Genus *Lophopodella* described)

1906 ANNANDALE, "Notes on the Freshwater Fauna of India No II The Affinities of *Hislopia*," J As Soc Bengal (new series) ii, p 59

1906 KRAEPELIN, "Eine Susswasser-bryozoe (*Plumatella*) aus Java," Mitth Mus Hamburg, xxiii, p 143

1907 ANNANDALE, "Notes on the Freshwater Fauna of India No XII The Polyzoa occurring in Indian Fresh and Brackish Pools," J As Soc Bengal (new series) iii, p 83

1907. ANNANDALE, "Statoblasts from the surface of a Himalayan Pond," Rec Ind Mus i, p 177

1907. ANNANDALE, "The Fauna of Brackish Ponds at Port Canning, Lower Bengal I—Introduction and Preliminary Account of the Fauna," Rec Ind Mus i, p 35

1907. ANNANDALE, "The Fauna of Brackish Ponds at Port Canning, Lower Bengal VI—Observations on the Polyzoa, with further notes on the Ponds," Rec Ind Mus i, p 197

1907 ANNANDALE, "Further Note on a Polyzoon from the Himalayas," Rec Ind Mus i, p 145

1907 ROUSSELET, "Zoological Results of the Third Tanganyika Expedition, conducted by Dr W A Cunnington, 1904-1905—Report on the Polyzoa," P Z Soc London, i, p 250 (*Plumatella tanganyikæ*)

1907 OKA, "Eine dritte Art von *Pectinatella* (*P davenporti*, n sp)," Zool Anz xxxi, p 716

1907. APSTEIN, "Das Plancton im Colombo-See auf Ceylon," Zool Jahrb (Syst) xxv, p 201 (*Plumatella* recorded)

1907 WALTON, "Notes on *Hislopia lacustris*, Carter," Rec Ind Mus i, p 177

1907–1908 OKA, "Zur Kenntnis der Susswasser-Bryozoenfauna von Japan," Annot Zool Japon, vi, p 117

1907–1908 OKA, "Ueber eine neue Gattung von Susserwasserbryozoen," Annot Zool Japon, vi, p 277

1908 ANNANDALE, "The Fauna of Brackish Ponds at Port Canning, Lower Bengal VII—Further Observations on the Polyzoa with the description of a new genus of Entoprocta," Rec Ind Mus ii, p 11

1908 ANNANDALE, "Corrections as to the Identity of Indian Phylactolæmata," Rec Ind Mus ii, p 110

1908 ANNANDALE, "Three Indian Phylactolæmata," Rec. Ind Mus ii, p 169

1908 KIRKPATRICK, "Description of a new variety of *Spongilla loricata*, Weltner," Rec Ind Mus ii, p 97 (*Hislopia* recorded from Burma)

1909 ANNANDALE, "Preliminary Note on a new genus of Phylactolæmatous Polyzoa," Rec Ind Mus iii, p 279

1909 ANNANDALE, "A new species of *Fredericella* from Indian Lakes," Rec Ind Mus iii p 373

1909 WALTON "Large Colonies of *Hislopia lacustris*," Rec Ind Mus iii, p 295

1910 ANNANDALE, "Materials for a Revision of the Phylactolæmatous Polyzoa of India," Rec Ind Mus v, p 37

1911 WEST and ANNANDALE, "Descriptions of Three Species of Algæ associated with Indian Freshwater Polyzoa," J As Soc Bengal (*ined*)

GLOSSARY OF TECHNICAL TERMS USED IN PART III

Brown body	A body formed in a zoœcium by the degeneration of a polypide as a preparation for its regeneration
Cardiac portion (of the stomach)	That part which communicates with the œsophagus
Collar .	A longitudinally pleated circular membrane capable of being thrust out of the orifice in advance of the lophophore and of closing together inside the zoœcium above the tentacles when they are retracted
Dorsal surface . .	(*Of zoœcium or polypide*) the surface nearest the mouth, (*of statoblast*) the surface furthest from that by which the statoblast is attached to the funiculus during development
Ectocyst . . .	The outer, structureless layer of the zoœcium
Emarginate (of a zoœcium)	Having a thin or defective triangular area in the ectocyst at the tip
Endocyst	The inner, living (cellular) layer of the zoœcium
Epistome . .	A leaf-like ciliated organ that projects upwards and forwards over the mouth between it and the anus
Funiculus	A strand of tissue joining the alimentary canal to the endocyst
Furrowed (of a zoœcium)	Having a thin or defective longitudinal linear streak in the ectocyst on the dorsal surface
Gizzard . . .	A chamber of the alimentary canal situated at the cardiac end of the stomach and provided internally with a structureless lining
Intertentacular organ	A ciliated tube running between the cavity of the zoœcium and the external base of the lophophore
Keeled (of a zoœcium) .	Having a longitudinal ridge on the dorsal surface

Lophophore .	The tentacles with the base to which they are attached
Marginal processes (of statoblast)	Chitinous hooked processes on the margin of the swim-ring (*q v.*)
Œsophagus .. .	That part of the alimentary canal which joins the mouth to the stomach
Orifice	The aperture through which the lophophore can be protruded from or retracted into the zoœcium
Parietal muscles ..	Transverse muscles running round the inner wall of the zoœcium
Parieto-vaginal muscles	Muscles that surround the orifice, running between the folds of the zoœcium in an oblique direction.
Polyparium .	The whole body of zoœcia and polypides which are in organic connection.
Polypide	The tentacular crown, alimentary canal, and retractor muscles of a polyzoon-individual
Pyloric portion (of the stomach)	That part which communicates with the intestine
Resting bud ..	An external bud provided with food-material in its cells, with a horny external coat and capable of lying dormant in unfavourable conditions
Retractor muscles	The muscles by the action of which the lophophore can be pulled back into the zoœcium
Statoblast	An internal bud arising from the funiculus, containing food-material in its cells, covered with a horny coat and capable of lying dormant in unfavourable conditions
Swim-ring .	A ring of polygonal air-spaces surrounding the statoblast
Ventral surface	(*Of zoœcium or polypide*) the surface nearest the anus, (*of statoblast*) the surface by which the statoblast is attached to the funiculus during development
Zoarium	The whole body of zoœcia which are in organic connection
Zoœcium	Those parts of the polyzoon-individual which constitute a case or "house" for the polypide

SYNOPSIS

OF THE

CLASSIFICATION OF THE POLYZOA.

I.

SYNOPSIS OF THE SUBCLASSES, ORDERS, AND SUBORDERS.

Class POLYZOA.

Small cœlomate animals, each individual of which consists of a polyp-like organism or polypide enclosed in a "house" or zoœcium composed partly of living tissues The mouth is surrounded by a circle of ciliated tentacles that can be retracted within the zoœcium, the alimentary canal, which is suspended in the zoœcium, is Y-shaped and consists of three parts, the œsophagus, the stomach, and the intestine

Subclass **ENTOPROCTA.**

The anus as well as the mouth is enclosed in the circle of tentacles and the zoœcium is not very distinctly separated from the polypide Some forms are solitary or form temporary colonies by budding

Most Entoprocta are marine, but a freshwater genus (*Urnatella*) occurs in N America, while the Indian genus *Loxosomatoides* (fig 34, p. 176) is only known from brackish water.

Subclass **ECTOPROCTA.**

The anus is outside the circle of tentacles and the zoœcium can always be distinguished from the polypide All species form by budding permanent communities the individuals in which remain connected together by living tissue

Order I. GYMNOLÆMATA.

Ectoproctous polyzoa the polypides of which have no epistome; the zoœcia are in nearly all cases distinctly separated from one another by transverse perforated plates

Most of the Gymnolæmata are marine, but species belonging to two of the three suborders into which they are divided often stray into brackish water, while a few genera that belong to one of these two suborders are practically confined to fresh water. The three suborders are distinguished as follows:—

Suborder A. *CHEILOSTOMATA.*

The zoœcia are provided with a "lip" or lid hinged to the posterior margin of the orifice (see fig 33, p 175) This lid closes automatically outside the zoœcium or in a special chamber on the external surface (the "peristome") when the polypide retracts and is pushed open by the tentacles as they expand. The majority of the zoœcia in each zoarium are more or less distinctly flattened, but some of them are often modified to form "vibracula" and "avicularia"

The Cheilostomata are essentially a marine group, but some species are found in estuaries and even in pools and ditches of brackish water (fig 33)

Suborder B *CTENOSTOMATA.*

The zoœcia are provided with a collar-like membrane which is pleated vertically and closes together above the polypide inside the zoœcium when the former is retracted, it is thrust out of the zoœcium and expands into a ring-shaped form just before the tentacles are extruded The zoœcia are usually more or less tubular, but in some genera and species are flattened.

The majority of the Ctenostomata are marine, but some genera are found in estuaries, while those of one section of the suborder live almost exclusively in fresh water

Suborder C *CYCLOSTOMATA.*

The zoœcia are provided neither with a lip nor with a collar-like membrane. They are tubular and usually have circular orifices

The Cyclostomata are exclusively marine.

Order II PHYLACTOLÆMATA

Ectoproctous polyzoa the polypides of which have a leaf-shaped organ called an epistome projecting upwards and forwards within the circle of tentacles and between the mouth and the anus The zooecia are not distinct from one another, but in dendritic forms the zoarium is divided irregularly by chitinous partitions

The Phylactolæmata are, without exception, freshwater species

II.

Synopsis of the leading Characters of the Divisions of the Suborder Ctenostomata

Suborder B. *CTENOSTOMATA*

The suborder has been subdivided in various ways by different authors The system here adopted is essentially the same as that proposed in a recent paper by Waters (Journ Linn Soc London, Zool xxi, p 231, 1910), but I have thought it necessary to add a fourth division to the three adopted by that author, namely, the Alcyonellea, Stolonifera, and Vesicularina This new division includes all the freshwater genera and may be known as the Paludicellina. In none of these divisions are the tentacles webbed at the base

The four divisions may be recognized from the following synopsis of their characteristic features —

Division I ALCYONELLEA

The zoœcia arise directly from one another in a fleshy or gelatinous mass. The polypide has no gizzard The species are essentially marine, but a few are found in brackish water in estuaries.

Division II STOLONIFERA.

The zoœcia arise from expansions in a delicate creeping rhizome or root-like structure, the order in which they are connected together being more or less irregular As a rule (perhaps always) there is no gizzard The species are marine

Division III VESICULARINA

The zoœcia grow directly from a tubular stem which is usually free and vertical, their arrangement being alternate, spiral or irregular. There is a stout gizzard which bears internal chitinous projections and is tightly compressed when the polypide is retracted The species are essentially marine, but a few are found in brackish water

Division IV PALUDICELLINA, nov.

The zoœcia are arranged in a regular cruciform manner and arise either directly one from another or with the intervention of tubular processes. If the polypide has a gizzard it does not bear internal chitinous projections Most of the species are confined to fresh water, but a few are found in brackish water or even in the sea

Although all true freshwater Ctenostomes belong to the fourth of these divisions, species of a genus (*Bowerbankia*) included in the third are so frequently found in brackish water and in association with one belonging to the fourth, and are so easily confounded with the latter, that I think it necessary to include a brief description of the said genus and of the form that represents it in ponds of brackish water in India

SYSTEMATIC LIST OF THE INDIAN FRESHWATER POLYZOA.

[The types have been examined in the case of all species, etc, whose names are marked thus, *.]

Order I. GYMNOLÆMATA.

Suborder I *CTENOSTOMATA*

[Division III **Vesicularina**]

[Genus Bowerbankia, Farre (1837)]

[*B caudata* subsp *bengalensis* *, Annandale (1907) (Brackish water)]

Division IV Paludicellina, nov

Family I PALUDICELLIDÆ

Genus 1 Paludicella, Gervais (1836)

? *Paludicella* sp (*fide* Carter)

Genus 2 Victorella, Kent (1870)

26 *V bengalensis* *, Annandale (1907)

Family II HISLOPIIDÆ

Genus Hislopia, Carter (1858)

27 *H lacustris*, Carter (1858).
27 *a*. *H lacustris* subsp *moniliformis* *, nov

Order II PHYLACTOLÆMATA.

Division I Plumatellina

Family 1 FREDERICELLIDÆ

Genus Fredericella, Gervais (1836).

28 *F. indica* *, Annandale (1909)

Family 2 PLUMATELLIDÆ

Subfamily A Plumatellinæ

Genus 1 Plumatella, Lamarck (1816)

29. *P fruticosa*, Allman (1844)
30 *P emarginata*, Allman (1844)
31. *P javanica* *, Kraepelin (1905)
32 *P. diffusa*, Leidy (1851)
33 *P allmani*, Hancock (1850)
34 *P tanganyikæ* *, Rousselet (1907).
35 *P punctata*, Hancock (1850).

Genus 2 Stolella, Annandale (1909)

36 *S indica* *, Annandale (1909).

Subfamily B Lophopinæ

Genus 1 Lophopodella, Rousselet (1904)

37 *L carteri* * (Hyatt) (1865)
37 a *L carteri* var *himalayana* * (Annandale) (1907)

Genus 2 Pectinatella, Leidy (1851).

38. *P burmanica* *, Annandale (1908)

Order CTENOSTOMATA.

[Division VESICULARINA

Family VESICULARIDÆ.

VESICULARIDÆ, Hincks, Brit Marine Polyzoa, p 512 (1880).

Zoœcia constricted at the base, deciduous, attached to a stem that is either recumbent or vertical

Genus BOWERBANKIA, *Farre*

Bowerbankia, Farre, Phil Trans Roy Soc cxxvii, p. 391 (1837)
Bowerbankia, Hincks, *op cit* p 518

Zoarium vertical or recumbent *Zoœcia* ovate or almost cylindrical, arranged on the stem singly, in clusters or in a subspiral line. *Polypide* with 8 or 10 tentacles

Bowerbankia caudata, *Hincks*

Bowerbankia caudata, Hincks, *op cit* p 521, pl lxxv, figs 7, 8.

This species is easily distinguished from all others by the fact that mature zoœcia have always the appearance of being fixed to the sides of a creeping, adherent stem and are produced, below the point at which they are thus fixed, into a pointed "tail"

Subsp. bengalensis, *Annandale.*

Bowerbankia caudata, Thornely, Rec Ind Mus. i, p. 196 (1907).
Bowerbankia caudata, Annandale, *ibid* p 203
Bowerbankia caudata race *bengalensis*, *id*, *ibid* ii p 13 (1908)

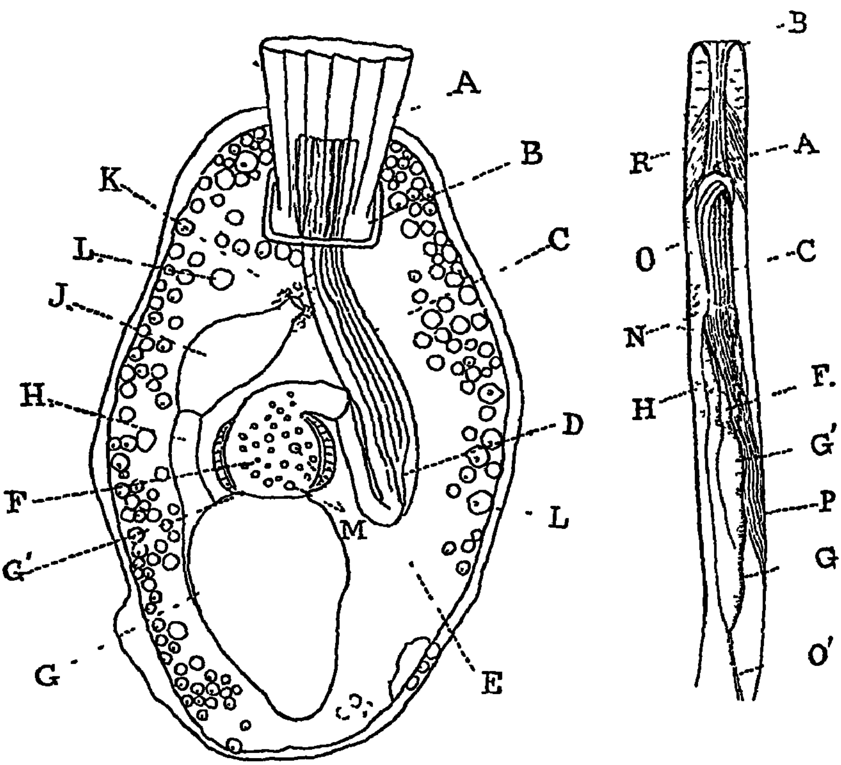
The Indian race is only distinguished from the typical form by its greater luxuriance of growth and by the fact that the "tail" of the zoœcia is often of relatively great length, sometimes equalling or exceeding the rest of the zoœcium. The stem, which is divided at irregular intervals by partitions, often crosses and recrosses its own course and even anastomoses, and a fur-like structure is formed in which the zoœcia representing the hairs become much elongated, but upright branches are never formed The zoarium has a greenish or greyish tinge

TYPE in the Indian Museum

GEOGRAPHICAL DISTRIBUTION —*B caudata* subsp *bengalensis* is common in brackish water in the Ganges delta, where it often occurs in close association with *Victorella bengalensis*, and also at the south end of the Chilka Lake in the north-east of the Madras Presidency Although it has not yet been found elsewhere, it probably occurs all round the Indian coasts]

Division PALUDICELLINA, nov.

This division consists of two very distinct families, the species of which are easily distinguished at a glance by the fact that in one (the Paludicellidæ) the zoœcia are tubular, while in the other (the Hislopiidæ) they are broad and flattened The anatomical and physiological differences between the two families are important, and they are associated together mainly on account of the method of budding by means of which their zoœcia are produced.



B A

Fig 35 —Single zoœcia of *Victorella* and *Hislopia* (magnified)

A, zoœcium of *Victorella pavida*, Kent, with the polypide retracted (after Kraepelin)

B, zoœcium of *Hislopia lacustris*, Carter (typical form from the United Provinces), with the collar completely and the tentacles partly protruded

A=collar, B=orifice, C=tentacles, D=pharynx, E=œsophagus proper, F=gizzard, G=stomach, G'=cardiac portion of stomach, H=intestine, J=rectum, K=anus, L=young egg, M=green cysts in gizzard, N=testes, O=ovary, O'=funiculus

The muscles are omitted except in fig B

Family PALUDICELLIDÆ

PALUDICELLIDÆ, Allman, Mon Fresh-Water Polyzoa, p 113 (1857)
HOMODIÆTIDÆ, Kent, Q J Micr Sci x, p. 35 (1870)
VICTORELLIDÆ, Hincks, Brit Marine Polyzoa, p 558 (1880)
PALUDICELLIDÉES, Jullien, Bull Soc zool France, x, p 174 (1885)
PALUDICELLIDES, Loppens, Ann Biol lacustre, iii, p 170 (1908)
VICTORELLIDES, *id*, *ibid* p 171

Zoarium The zoarium is recumbent or erect, and is formed typically either of zoœcia arising directly in cruciform formation from one another, or of zoœcia joined together in similar formation with the intervention of tubules arising from their own bases Complications often arise, however, either on account of the suppression of the lateral buds of a zoœcium, so that the formation becomes linear instead of cruciform, or by the production in an irregular manner of additional tubules and buds from the upper part of the zoœcia A confused and tangled zoarium may thus be formed, the true nature of which can only be recognized by the examination of its terminal parts

Zoœcia The zoœcia are tubular and have a terminal or subterminal orifice, which is angulate or subangulate as seen from above Owing to this fact, to the stiff nature of the external ectocyst, to the action of circular muscles that surround the tentacular sheath, and to the cylindrical form of the soft inverted part, the orifice, as seen from above, appears to form four flaps or valves, thus .

Polypide The alimentary canal is elongate and slender as a whole, the œsophagus (including the pharynx) being of considerable length In *Paludicella* and *Pottsiella* the œsophagus opens directly into the cardiac limb of the stomach, which is distinctly constricted at its base, but in *Victorella* the base of the œsophagus is constricted off from the remainder to form an elongate oval sac the walls of which are lined with a delicate structureless membrane *Victorella* may therefore be said to possess a gizzard, but the structure that must be so designated has not the function (that of crushing food) commonly associated with the name, acting merely as a chamber for the retention of solid particles In this genus the cardiac limb of the stomach is produced and vertical but not constricted at the base The tentacles in most species number 8, but in *Paludicella* there are 16

Resting buds The peculiar structures known in Europe as "hibernacula" are only found in this family The name hibernacula, however, is inappropriate to the only known Indian species

as they are formed in this country at the approach of summer instead of, as in Europe and N America, at that of winter It is best, therefore, to call them "resting buds" They consist of masses of cells congregated at the base of the zoœcia, gorged with food material and covered with a resistant horny covering

The family Paludicellidæ consists of three genera which may be distinguished as follows —

I Orifice terminal, main axis of the zoœcium vertical, zoœcia separated from one another by tubules

[A Base of the zoœcia not swollen, no adventitious buds . . . POTTSIELLA]

B Base of the zoœcium swollen, adventitious buds produced near the tip . . . VICTORELLA, [p 194.

II Orifice subterminal, distinctly on the dorsal surface, main axis of the zoœcium horizontal (the zoarium being viewed from the dorsal surface), buds not produced at the tip of the zoœcia . . . PALUDICELLA, [p. 192

Of these three genera, *Pottsiella* has not yet been found in India and is only known to occur in N. America. It consists of one species, *P erecta* (Potts) from the neighbourhood of Philadelphia in the United States

Victorella includes four species, *V pavida* known from England and Germany and said to occur in Australia, *V mulleri* from Germany (distinguished by possessing parietal muscles at the tip of the zoœcia), *V symbiotica* from African lakes and *V bengalensis* from India These species are closely related

Paludicella is stated by Carter to have been found in Bombay, but probably what he really found was the young stage of *V. bengalensis* A single species is known in Europe and N America, namely *P ehrenbergi*, van Beneden (=*Alcyonella articulata*, Ehrenberg)

I have examined specimens of all the species of this family as yet known

Genus 1 PALUDICELLA, *Gervais*

Paludicella, Gervais, Compt Rend iii, p 797 (1836)
Paludicella, Allman, Mon Fresh-Water Polyzoa, p 113 (1857)
? *Paludicella*, Carter, Ann Nat Hist (3) iii, p 333 (1859)
Paludicella, Jullien Bull Soc zool France, x, p 174 (1885)
Paludicella, Kraepelin, Deutsch Susswasserbryozoen, i, p 96 (1887)
Paludicella, Loppens, Ann Biol lacustre, iv, p 14 (1910)

Zoarium The nature of the zoarium in this genus is well expressed by Ehrenberg's specific name "*articulata*," although the name was given under a false impression The zoœcia arise directly from one another in linear series with occasional side-branches The side-branches are, however, often suppressed The zoarium as a whole is either recumbent and adherent or at least partly vertical

Zooecia. Although the zooecia are distinctly tubular as a whole, two longitudinal axes may be distinguished in each, for the tip is bent upwards in a slanting direction, bearing the orifice at its extremity. The main axis is, however, at right angles to the dorso-ventral axis, and the dorsal surface, owing to the position of the aperture, can always be readily distinguished from the ventral, even when the position of the zooecium is vertical. Each zooecium tapers towards the posterior extremity. Parietal muscles are always present.

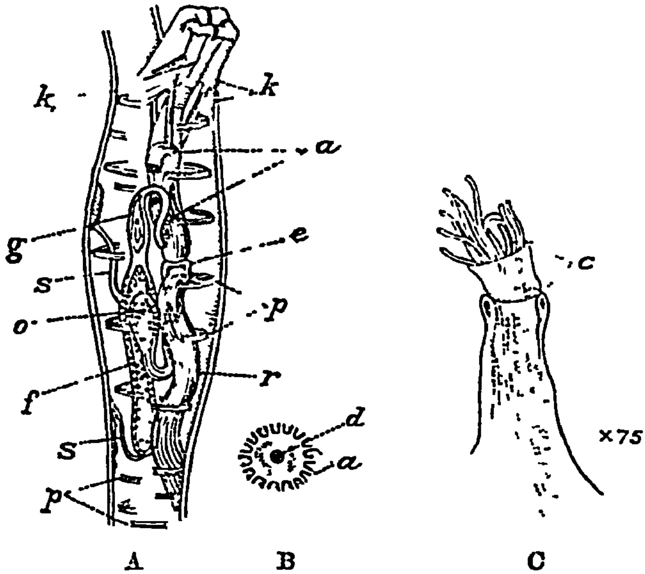


Fig 36.—Structure of *Paludicella ehrenbergi* (A and B after Allman).

A = a single zooecium with the polypide retracted. B = the base of the lophophore as seen from above with the tentacles removed. C = the orifice of a polypide with the collar expanded and the tentacles partly retracted. *a* = tentacles, *c* = collar, *d* = mouth, *e* = oesophagus, *f* = stomach, *g* = intestine, *k* = parieto-vaginal muscles, *p* = parietal muscles, *o* = cardiac part of the stomach, *r* = retractor muscle, *s* = funiculus.

Polypide. The most striking features of the polypide are the absence of any trace of a gizzard and the highly specialized form assumed by the cardiac part of the stomach. There are two funiculi, both connecting the pyloric part of the stomach with the endocyst. The ovary develops at the end of the upper, the testis at that of the lower funiculus.

Resting buds. The resting buds are spindle-shaped.

Kraepelin recognized two species in the genus mainly by their method of growth and the number of tentacles. In his *P. mulleri* the zoarium is always recumbent and the polypide has 8 tentacles, whereas in *P. articulata* or *ehrenbergi* the tentacles number 16 and upright branches are usually developed. It is probable,

however, that the former species should be assigned to *Victorella*, for it is often difficult to distinguish *Paludicella* from young specimens of *Victorella* unless the latter bear adventitious terminal buds. The gizzard of *Victorella* can be detected in well-preserved material even under a fairly low power of the microscope, and I have examined specimens of what I believe to be the adult of *mulleri* which certainly belong to that genus.

It is always difficult to see the collar of *Paludicella*, because of its transparency and because of the fact that its pleats are apparently not strengthened by chitinous rods as is usually the case. Allman neither mentions it in his description of the genus nor shows it in his figures, and Loppens denies its existence, but it is figured by Kraepelin and can always be detected in well-preserved specimens, if they are examined carefully. If the collar were actually absent, its absence would separate *Paludicella* not only from *Victorella* and *Pottsiella*, but also from all other ctenostomes. In any case, *Victorella* is distinguished from *Paludicella* and *Pottsiella* by anatomical peculiarities (*e g.*, the possession of a gizzard and the absence of a second funiculus) that may ultimately be considered sufficiently great to justify its recognition as the type and only genus of a separate family or subfamily.

The description of *Paludicella* is included here on account of Carter's identification of the specimens he found at Bombay; but its occurrence in India is very doubtful.

Genus 2 VICTORELLA, *Kent*

Victorella, Kent, Q. J. Micr. Sci. x, p. 34 (1870).
Victorella, Hincks, Brit. Marine Polyzoa, p. 559 (1880).
Victorella, Kraepelin, Deutsch. Susswasserbryozoen, i, p. 93 (1887).

TYPE, *Victorella pavida*, Kent.

Zoarium. The zoarium consists primarily of a number of erect or semi-erect tubular zoœcia joined together at the base in a cruciform manner by slender tubules, but complications are introduced by the fact that adventitious buds and tubules are produced, often in large numbers, round the terminal region of the zoœcia, and that these buds are often separated from their parent zoœcium by a tubule of considerable length, and take root among other zoœcia at a distance from their point of origin. A tangled mass may thus be formed in which it is difficult to recognize the regular arrangement of the zoœcia that can be readily detached at the growing points of the zoarium.

Zoœcia. The zoœcia when young closely resemble those of *Paludicella*, but as they grow the terminal upturned part increases rapidly, while the horizontal basal part remains almost stationary and finally appears as a mere swelling at the base of an almost vertical tube, in which by far the greater part, if not the whole, of the polypide is contained. Round the terminal part of this

tube adventitious buds and tubules are arranged more or less regularly. There are no parietal muscles

Polypide The polypide has 8 slender tentacles, which are thickly covered with short hairs The basal part of the œsophagus forms a thin-walled sac (the "gizzard") constricted off from the upper portion and bearing internally a thin structureless membrane. Circular muscles exist in its wall but are not strongly developed on its upper part There is a single funiculus, which connects the posterior end of the stomach with the base of the zoœcium. The ovaries and testes are borne on the endocyst, not in connection with the funiculus

Resting buds The resting buds are flattened or resémble young zoœcia in external form

Victorella, although found in fresh water, occurs more commonly in brackish water and is known to exist in the littoral zone of the sea

26 Victorella bengalensis, *Annandale*

Victorella pavida, Annandale (*nec* Kent), Rec Ind Mus i, p 200, figs 1-4 (1907)
Victorella bengalensis, *id*, *ibid*. ii, p 12, fig 1 (1908)

Zoarium. The mature zoarium resembles a thick fur, the hairs of which are represented by elongate, erect, slender tubules (the zoœcia), the arrangement of the whole being very complicated and irregular The base of the zoarium often consists of an irregular membrane formed of matted tubules, which are sometimes agglutinated together by a gummy secretion The zoarium as a whole has a faint yellowish tinge.

Zoœcia. The zoœcia when young are practically recumbent, each being of an ovoid form and having a stout, distinctly quadrate orificial tubule projecting upwards and slightly forwards near the anterior margin of the dorsal surface At this stage a single tubule, often of great relative length, is often given off near the orifice, bearing a bud at its free extremity As the zoœcium grows the tubular part becomes much elongated as compared with the basal part and assumes a vertical position Its quadrate form sometimes persists but more often disappears, so that it becomes almost circular in cross-section throughout its length. Buds are produced near the tip in considerable profusion As a rule, if they appear at this stage, the tubule connecting them with the parent zoœcium is short or obsolete; sometimes they are produced only on one side of the zoœcium, sometimes on two The buds themselves produce granddaughter and great-granddaughter buds, often connected together by short tubules, while still small and imperfectly developed The swelling at the base of the zoœcium, when the latter is fully formed, is small.

Polypide The polypide has the features characteristic of the genus The base of the gizzard is surrounded by a strong circular muscle

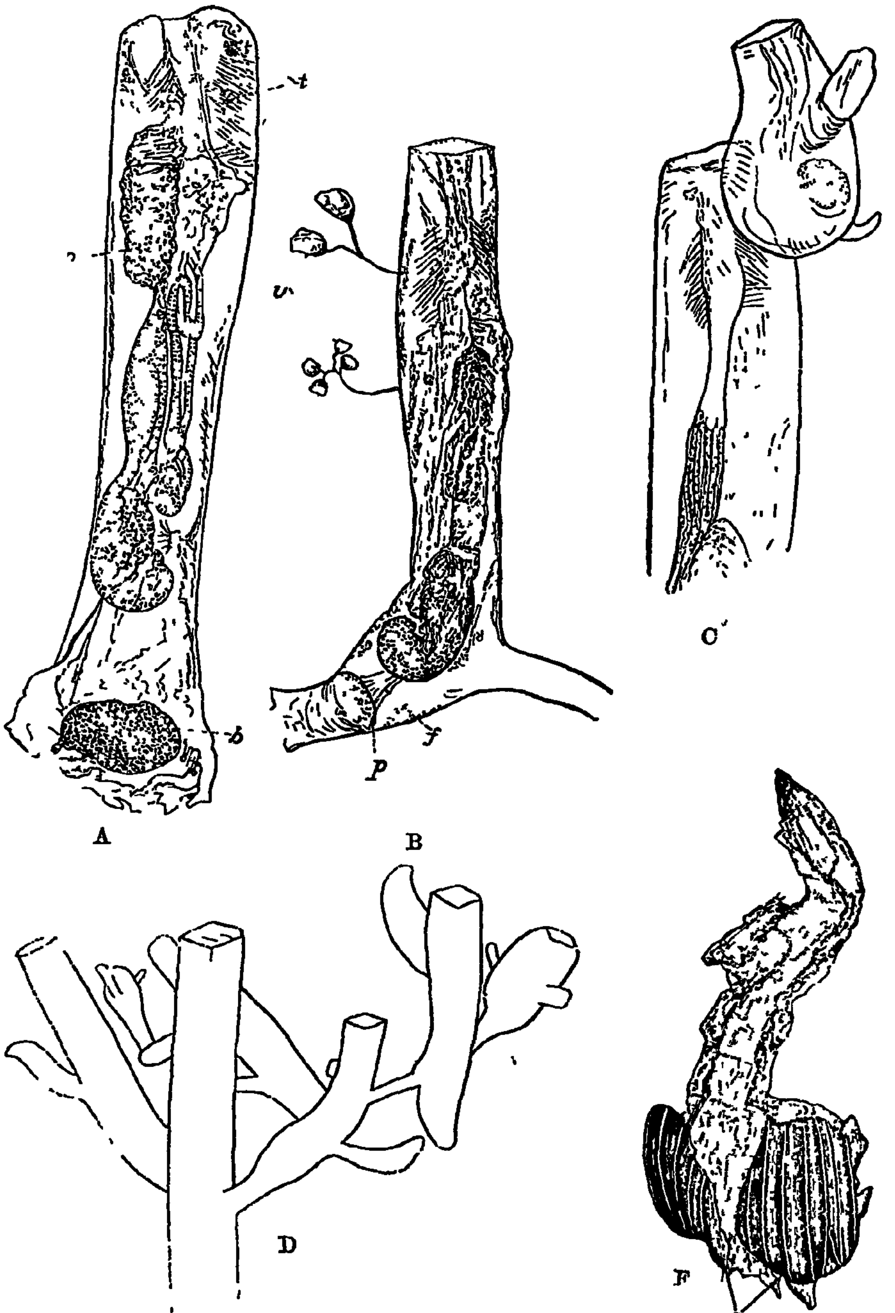


Fig 37 —*Victorella bengalensis* (type specimens)

A=single zoœcium without adventitious buds but with a young resting bud (*b*), × 70 (dorsal view), B=lateral view of a smaller zoœcium without buds, × 70, C=upper part of a zoœcium with a single adventitious bud, × 70, D=outline of the upper part of a zoœcium with adventitious buds of several generations, × 35, E=remains of a zoœcium with two resting buds (*b*) attached All the specimens figured are from Port Canning and, except D, are represented as they appear when stained with borax carmine and mounted in canada balsam

Resting buds The resting buds (fig. 31, p 170) are somewhat variable in shape but are always flat with irregular cylindrical or subcylindrical projections round the margin, on which the horny coat is thinner than it is on the upper surface This surface is either smooth or longitudinally ridged

TYPE in the Indian Museum

This species differs from the European *V pavida* in very much the same way as, but to a greater extent than, the Indian race of *Bowerbankia caudata* does from the typical English one (see p 189). The growth of the zoarium is much more luxuriant, and the form of the resting buds is different

GEOGRAPHICAL DISTRIBUTION —*V bengalensis* is abundant in pools of brackish water in the Ganges delta and in the Salt Lakes near Calcutta, it also occurs in ponds of fresh water near the latter I have received specimens from Madras from Dr J R. Henderson, and it is probable that the form from Bombay referred by Carter to *Paludicella* belonged to this species

BIOLOGY —In the Ganges delta *V bengalensis* is usually found coating the roots and stems of a species of grass that grows in and near brackish water, and on sticks that have fallen into the water It also spreads over the surface of bricks, and I have found a specimen on a living shell of the common mollusc *Melania tuberculata* Dr Henderson obtained specimens at Madras from the surface of a freshwater shrimp, *Palæmon malcolmsonii* In the ponds at Port Canning the zoaria grow side by side with, and even entangled with those of *Bowerbankia caudata* subsp *bengalensis*, to the zooecia of which their zooecia bear a very strong external resemblance so far as their distal extremity is concerned This resemblance, however, disappears in the case of zooecia that bear terminal buds, for no such buds are borne by *B caudata*, and the yellowish tint of the zoaria of *V bengalensis* is characteristic Zoaria of the entoproct *Loxosomatoides colonialis* and colonies of the hydroid *Irene ceylonensis* are also found entangled with the zoaria of *V. bengalensis*, the zooecia of which are often covered with various species of Vorticellid protozoa and small rotifers The growth of *V bengalensis* is more vigorous than that of the other polyzoa found with it, and patches of *B caudata* are frequently surrounded by large areas of *V bengalensis*

The food of *V bengalensis* consists largely of diatoms, the siliceous shells of which often form the greater part of its excreta Minute particles of silt are sometimes retained in the gizzard, being apparently swallowed by accident

There are still many points to be elucidated as regards the production and development of the resting buds in *V bengalensis*, but two facts are now quite clear as regards them firstly, that these buds are produced at the approach of the hot weather and germinate in November or December and secondly, that the whole zoarium may be transformed at the former season into a layer of resting buds closely pressed together but sometimes exhibiting in their arrangement the typical cruciform formation Resting buds may often be found in vigorous colonies as late as

the beginning of December, these buds have not been recently formed but have persisted since the previous spring and have not yet germinated. Sometimes only one or two buds are formed at the base of an existing zooecium (fig. 37 *a*), but apparently it is possible not only for a zooecium to be transformed into a resting bud but for it to produce four other buds round its base before undergoing the change. Young polypides are formed inside the buds and a single zooecium sprouts out of each, as a rule by the growth of one of the basal projections, when conditions are favourable.

Polypides of *V. bengalensis* are often transformed into brown bodies. When this occurs the orifice closes together, with the collar expanded outside the zooecium. I have occasionally noticed that the ectocyst of such zooecia was distinctly thicker and darker in colour than that of normal zooecia.

Eggs and spermatozoa are produced in great numbers, as a rule simultaneously in the same zooecia, but individuals kept in captivity often produce spermatozoa only. The eggs are small and are set free as eggs. Nothing is known as regards their development.

Polypides are as a rule found in an active condition only in the cold weather, but I have on one occasion seen them in this condition in August, in a small zoarium attached to a shell of *Melania tuberculata* taken in a canal of brackish water near Calcutta.

Family HISLOPIIDÆ.

HISLOPIDÉES, Jullien, Bull Soc Zool France, x, p 180 (1885)
HISLOPIIDÆ, Annandale, Rec Ind Mus i, p 200 (1907)

Zoarium recumbent, often forming an almost uniform layer on solid subjects

Zoœcia flattened, adherent, the orifice dorsal, either surrounded by a chitinous rim or situated at the tip of an erect chitinous tubule; no parietal muscles

Polypide with an ample gizzard which possesses a uniform chitinous lining and does not close together when the polypide is retracted

Resting bud, not produced.

Only two genera can be recognized in this family, *Arachnoidea*, Moore, from Central Africa, and *Hislopia*, Carter, which is widely distributed in Eastern Asia The former genus possesses an upright orificial tubule and has zoœcia separated by basal tubules Its anatomy is imperfectly known, but it certainly possesses a gizzard of similar structure to that of *Hislopia*, between which and *Victorella* its zoœcium is intermediate in form

Genus HISLOPIA, *Carter*

Hislopia, Carter, Ann Nat Hist (3) i, p 169 (1858)
Hislopia, Stoliczka, J As Soc Bengal, xxxviii (2), p 61 (1869)
Norodonia, Jullien, Bull Soc Zool France, v, p 77 (1880)
Hislopia, *id*, *ibid* x, p 183 (1885)
Norodonia, *id*, *ibid* p 180
Echinella, Korotneff, Biol Centralbl xxi, p 311 (1901)
Hislopia, Annandale, J As Soc Bengal (new series) ii, p 59 (1906)
Hislopia, Loppens, Ann Biol lacustre, iii, p 175 (1908)

TYPE, *Hislopia lacustris*, Carter.

Zoarium The zoarium consists primarily of a main axis running in a straight line, with lateral branches that point forwards and outwards Further proliferation, however, often compacts the structure into an almost uniform flat area.

Zoœcia. The zoœcia (fig 35 B, p 190) are flat and have the orifice surrounded by a chitinous rim but not much raised above the dorsal surface They arise directly one from another

Polypide The polypide possesses from 12 to 20 tentacles Its funiculus is rudimentary or absent Neither the ovaries nor the testes have any fixed position on the lateral walls of the zoœcium to which they are confined.

The position of this genus has been misunderstood by several zoologists Carter originally described *Hislopia* as a cheilostome allied to *Flustra*, in 1880 Jullien perpetuated the error in

describing his *Norodonia*, which was founded on dried specimens of Carter's genus, while Loppens in 1908 still regarded the two "genera" as distinct and placed them both among the cheilostomes. In 1885, however, Jullien retracted his statement that *Norodonia* was a cheilostome and placed it, together with *Hislopia*, in a family of which he recognized the latter as the eponymic genus. Carter's mistake arose from the fact that he had only examined preserved specimens, in which the thickened rim of the orifice is strongly reminiscent of the "peristome" of certain cheilostomes, while the posterior of the four folds into which the tentacle sheath naturally falls (as in all ctenostomes, *cf* the diagram on p. 191) is in certain conditions rather larger than the other three and suggests the "lip" characteristic of the cheilostomes. If living specimens are examined, however, it is seen at once that the posterior fold, like the two lateral folds and the anterior one, changes its form and size from time to time and has no real resemblance to a "lip".

That there is a remarkable, if superficial, resemblance both as regards the form of the zoœcium and as regards the method of growth between *Hislopia* and certain cheilostomes cannot be denied, but the structure of the orifice and indeed of the whole organism is that of a ctenostome and the resemblance must be regarded as an instance of convergence rather than of genetic relationship.

The most striking feature of the polypide of *Hislopia* is its gizzard (fig. 38, p. 201) which is perhaps unique (except for that of *Arachnoidea*) both in structure and function. In structure its peculiarities reside mainly in three particulars: (i), it is not constricted off directly from the thin-walled œsophageal tube, but possesses at its upper extremity a thick-walled tubular portion which can be entirely closed from the œsophagus at its upper end but always remains in communication with the spherical part of the gizzard; (ii), this spherical part of the gizzard is uniformly lined with a thick chitinous or horny layer which in optical section has the appearance of a pair of ridges; and (iii), there is a ring of long and very powerful cilia round the passage from the gizzard to the stomach. The cardiac limb of the stomach, which is large and heart-shaped, is obsolete. The wall of the spherical part of the gizzard consists of two layers of cells, an outer muscular layer consisting of powerful circular muscles and an inner glandular layer, which secretes the chitinous lining. The inner walls of the tubular part consist of non-ciliated columnar cells, and when the polypide is retracted it lies almost at right angles to the main axis of the zoœcium.

The spherical part of the gizzard invariably contains a number of green cells, which lie free in the liquid it holds and are kept in motion by the cilia at its lower aperture. The majority of these cells can be seen with the aid of a high power of the microscope to consist of a hard spherical coat or cyst containing green protoplasm in which a spherical mass of denser substance (the nucleus) and a number of minute transparent granules can

sometimes be detected The external surface of many of the cysts is covered with similar granules, but some are quite clean

There can be no doubt that these cysts represent a stage in the life-history of some minute unicellular plant or animal Indeed, although it has not yet been found possible to work out this life-history in detail, I have been able to obtain much evidence that they are the resting stage of a flagellate organism allied to *Euglena* which is swallowed by the polyzoon and becomes encysted in its gizzard, extruding in so doing from its external surface a large proportion of the food-material that it has stored up within itself in the form of transparent granules It may also be stated that some of the organisms die and disintegrate on being received into the gizzard, instead of encysting themselves

So long as the gizzard retains its spherical form the green cells and its other contents are prevented from entering the stomach by the movements of the cilia that surround its lower aperture, but

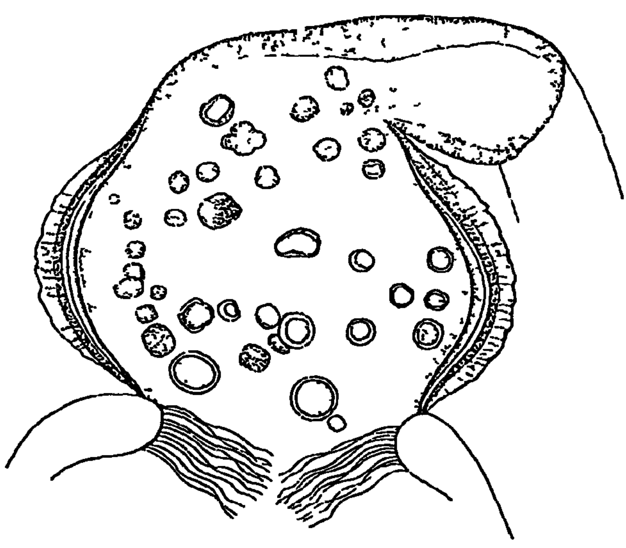


Fig 38 —Optical section of gizzard of *Hislopia lacustris* with contained green cysts, × 240

every now and then, at irregular intervals, the muscles that form its outer wall contract The chitinous lining although resilient and not inflexible is too stiff to prevent the lumen of the gizzard being obliterated, but the action of the muscles changes its contents from a spherical to an ovoid form and in so doing presses a considerable part of them down into the stomach, through the ring of the cilia

The contraction of the gizzard is momentary, and on its re-expansion some of the green cysts that have entered the stomach are often regurgitated into it Some, however, remain in the stomach,

in which they are turned round and round by the action of the cilia at both apertures They are apparently able to retain their form for some hours in these circumstances but finally disintegrate and disappear, being doubtless digested by the juices poured out upon them by the glandular lining of the stomach In polypides kept under observation in clean tap-water all the cysts finally disappear, and the fæces assume a green colour In preserved specimens apparently unaltered cysts are sometimes found in the rectum, but this is exceptional, I have observed nothing of the kind in living polypides Cysts often remain for several days unaltered in the gizzard

Imperfect as these observations are, they throw considerable light on the functions of the gizzard in *Hislopia* Primarily it appears to act as a food-reservoir in which the green cysts and other minute organisms can be kept until they are required for digestion When in the gizzard certain organisms surrender a large proportion of the food-material stored up for their own uses, and this food-material doubtless aids in nourishing the polyzoon. Although the cysts in the gizzard are frequently accompanied by diatoms, the latter are not invariably present The cysts, moreover, are to be found in the zoœcia of polypides that have formed brown bodies, often being actually enclosed in the substance of the brown body The gizzards of the specimens of *Arachnoidea* I have examined contain cysts that resemble those found in the same position in *Hislopia*

Hislopia is widely distributed in the southern part of the Oriental Region, and, if I am right in regarding *Echinella*, Korotneff as a synonym, extends its range northwards to Lake Baikal It appears to be a highly specialized form but is perhaps related, through *Arachnoidea*, to *Victorella*

27 **Hislopia lacustris**, *Carter*

Hislopia lacustris, Carter, Ann Nat Hist (3) i, p 170, pl vii, figs 1–3 (1858)
Norodonia cambodgiensis, Jullien, Bull Soc zool France, v, p 77, figs 1–3 (1880)
Norodonia sinensis, *id*, *ibid* p 78, figs 1–3
Norodonia cambodgiensis, *id*, *ibid* x, p 181, figs 244, 245 (1885)
Norodonia sinensis, *id* *ibid* p. 182, figs 246, 247
Hislopia lacustris, Annandale, J. As Soc Bengal (new series) iii, p 85 (1907)
Hislopia lacustris, Walton, Rec Ind Mus i, p 177 (1907)
Hislopia lacustris, Kirkpatrick, *ibid* ii, p 98 (1908)
Hislopia lacustris, Walton, *ibid* iii, p 295 (1909)

Zoarium The zoarium forms a flat, more or less solid layer and is closely adherent to foreign objects As a rule it covers a considerable area, with radiating branches at the edges, but when growing on slender twigs or the stems of water-plants it forms

narrow, closely compressed masses One zoœcium, however, never grows over another

Zoœcia The zoœcia are variable in shape In zoaria which have space for free expansion they are as a rule irregularly oval, the posterior extremity being often narrower than the anterior; but small triangular zoœcia and others that are almost square may often be found When growing on a support of limited area the zoœcia are smaller and as a rule more elongate The orifice is situated on a slight eminence nearer the anterior than the posterior margin of the dorsal surface It is surrounded by a strong chitinous rim, which is usually square or subquadrate but not infrequently circular or subcircular Sometimes a prominent spine is borne at each corner of the rim, but these spines are often vestigial or absent, they are rarely as long as the transverse diameter of the orifice The zoœcium is usually surrounded by a

A

B

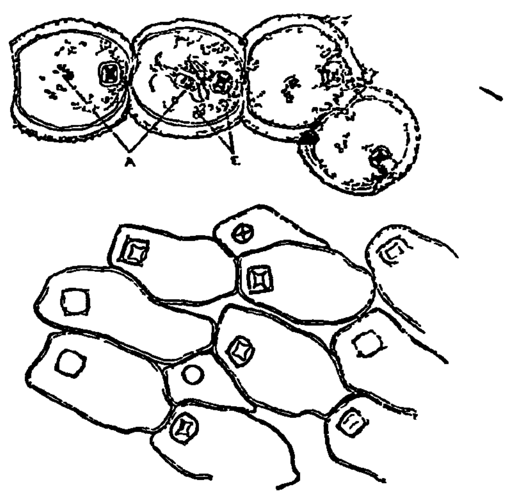


Fig 39 —*Hislopia lacustris*

A=part of a zoarium of the subspecies *moniliformis* (type specimen, from Calcutta), × 15, A=green cysts in gizzard, E=eggs

B=outline of part of a zoarium of the typical form of the species from the United Provinces, showing variation in the form of the zoœcia and of the orifice, × 15

chitinous margin, and outside this margin there is often a greater or less extent of adherent membrane. In some zoœcia the margin is obsolete or obsolescent. The dorsal surface is of a glassy transparency but by no means soft.

Polypide The polypide has from 12 to 20 tentacles, 16 being a common number

TYPE probably not in existence It is not in the British Museum and Prof. Dendy, who has been kind enough to examine the specimens from Carter's collection now in his possession, tells me that there are none of *Hislopia* among them

27 *a* Subsp moniliformis, nov

Hislopia lacustris, Annandale, J As Soc Bengal (new series) ii, p 59, fig 1 (1906)

In this race, which is common in Calcutta, the zooecia are almost circular but truncate or concave anteriorly and posteriorly They form linear series with few lateral branches I have found specimens occasionally on the shell of *Vivipara bengalensis*, but they are much more common on the leaves of *Vallisneria spiralis*

TYPE in the Indian Museum

The exact status of the forms described by Jullien as *Norodonia cambodgiensis* and *N. sinensis* is doubtful, but I see no reason to regard them as specifically distinct from *H lacustris*, Carter, of which they may be provisionally regarded as varieties The variety *cambodgiensis* is very like my subspecies *moniliformis* but has the zooecia constricted posteriorly, while var *sinensis*, although the types were found on *Anodonta* shells on which there was plenty of room for growth, resemble the confined phase of *H lacustris* so far as the form of their zooecia and of the orifice is concerned

GEOGRAPHICAL DISTRIBUTION —The typical form is common in northern India and occurs also in Lower Burma; the subspecies *moniliformis* appears to be confined to Lower Bengal, while the varieties *cambodgiensis* and *sinensis* both occur in China, the former having been found also in Cambodia and Siam Indian and Burmese localities are —BENGAL, Calcutta (subsp. *moniliformis*), Berhampur, Murshidabad district (*J Robertson Milne*) CENTRAL PROVINCES, Nagpur (*Carter*) UNITED PROVINCES, Bulandshahr (*H J Walton*) BURMA, Pegu-Sittang Canal (*Kirkpatrick*)

BIOLOGY —Regarding the typical form of the species Major Walton writes (Rec Ind Mus iii, p. 296) —"In volume i (page 177) of the Records of the Indian Museum, I described the two forms of colonies of *Hislopia* that I had found in the United Provinces (Bulandshahr) Of these, one was a more or less linear arrangement of the zooecia on leaves and twigs, and the other, and more common, form was an encrusting sheath on the outer surface of the shells of *Paludina*. During the present 'rains' (July 1908) I have found many examples of what may be considered a much exaggerated extension of the latter form These colonies have been on bricks, tiles, and other submerged objects. The largest colony that I have seen so far was on a tile, one side of the tile was exposed above the mud of the bottom of the tank, and its area measured about 120 square inches; the entire surface was almost completely covered by a continuous growth of *Hislopia* Another large colony was on a piece of bark which measured 7 inches by 3 inches; both sides were practically everywhere covered by *Hislopia* "

Major Walton also notes that in the United Provinces the growth of *Hislopia* is at its maximum during the "rains," and that at that time of year almost every adult *Paludina* in a certain

tank at Bulandshahr had its shell covered with the zooecia The Calcutta race flourishes all the year round but never forms large or closely compacted zoaria, those on shells of *Vivipara* exactly resembling those on leaves of *Vallisneria*

In Calcutta both eggs and spermatozoa are produced at all times of the year simultaneously in the same zooecia, but the eggs in one zooecium often vary greatly in size When mature they reach relatively considerable dimensions and contain a large amount of food material but they are set free from the zooecium as eggs They lie loose in the zooecium at a comparatively small size and grow in this position Nothing is known as regards the development of *Hislopia*

Both forms of the species appear to be confined to water that is free from all traces of contamination with brine

Order PHYLACTOLÆMATA

The polypide in this order possesses a leaf-like ciliated organ (the epistome) which arises within the lophophore between the mouth and the anus and projects upwards and forwards over the mouth, which it can be used to close The zoœcia are never distinct from one another, but in dendritic forms such as *Plumatella* the zoarium is divided at irregular intervals by chitinous partitions The lophophore in most genera is horseshoe-shaped instead of circular, the part opposite the anus being deeply indented There are no parietal muscles The orifice of the zoœcium is always circular, and there is no trace of any structure corresponding to the collar of the ctenostomes The tentacles are always webbed at the base

All the phylactolæmata produce the peculiar reproductive bodies known as statoblasts

The phylactolæmata, which are probably descended from ctenostomatous ancestors, are confined to fresh or slightly brackish water Most of the genera have a wide geographical distribution, but (with the exception of a few statoblasts of almost recent date) only one fossil form (*Plumatellites*, Fric from the chalk of Bohemia) has been referred to the order, and that with some doubt

It is convenient to recognize two main divisions of the phylactolæmata, but these divisions hardly merit the distinction of being regarded as suborders They may be called Cristatellina and Plumatellina and distinguished as follows —

Division I, PLUMATELLINA, nov —Ectocyst well developed, zoaria without a special organ of progression polypides contained in tubes

Division II, CRISTATELLINA, nov —Ectocyst absent except at the base of the zoarium which is modified to form a creeping "sole", polypides embedded in a common synœcium of reticulate structure

The Cristatellina consist of a single genus and probably of a single species (*Cristatella mucedo*, Cuvier), which is widely distributed in Europe and N America, but has not been found in the Oriental Region Eight genera of Plumatellina are known, and five (possibly six) of these genera occur in India

Division PLUMATELLINA, nov

The structure of the species included in this division is very uniform as regards the internal organs (see fig 40 opposite and fig 47 *a*, p 236) The alimentary canal is simpler than that of the Paludicellidæ A short œsophagus leads directly into the stomach,

the cardiac portion of which is produced as a vertical limb almost cylindrical in form and not constricted at the base This limb is as a rule of greater length than the œsophagus The pyloric part of the stomach is elongated and narrow, and the intestine short, straight, and of ovoid form There are no cilia at the pyloric opening A single funiculus joins the posterior end of the stomach to the wall of the zoœcium, bearing the statoblasts Sexual organs are often absent

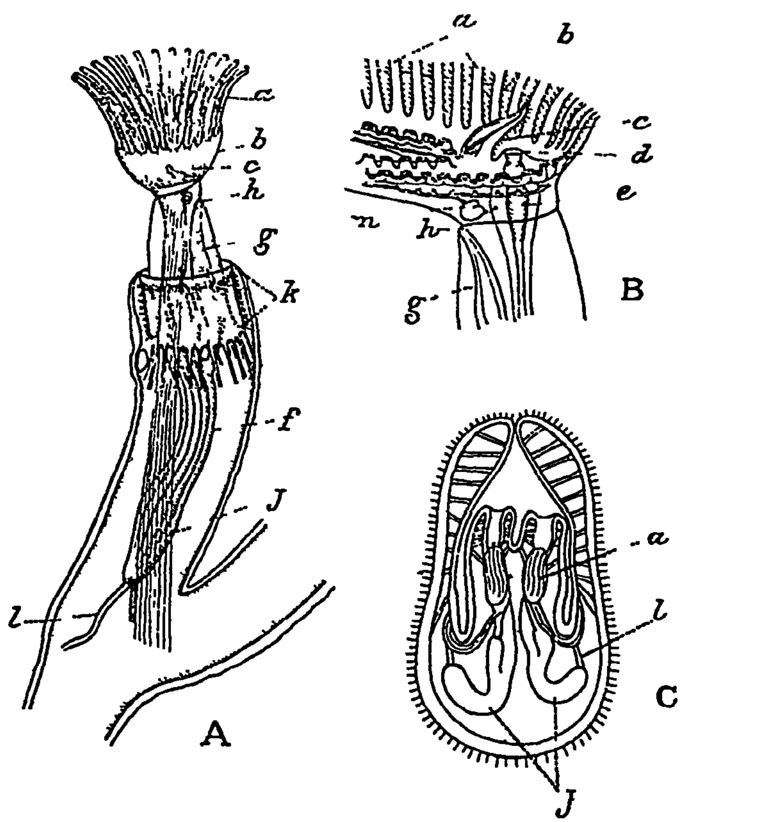


Fig 40 —Structure of the Plumatellina (after Allman)

A = a zoœcium of *Fredericella* with the polypide extruded B = the lophophore of *Lophopus* (tentacles removed) as seen obliquely from the right side C = larva of *Plumatella* as seen in optical section *a* = tentacles, *b* = velum, *c* = epistome, *d* = mouth, *e* = œsophagus, *f* = stomach, *g* = intestine, *h* = anus, *j* = retractor muscle, *k* = parieto-vaginal muscles, *l* = funiculus

Two families may be recognized as constituting the division, *viz*, (*a*) the Fredericellidæ, which have a circular or oval lophophore and simple statoblast without a swim-ring, and (*b*) the Plumatellidæ, in which the lophophore is shaped like a horseshoe and some or all of the statoblasts are provided with a ring of air-spaces

Family 1. FREDERICELLIDÆ

FREDERICELLIDÆ, Kraepelin, Deutsch Susswasserbryozoen, i, p 168 (1887)

Zoaria dendritic, *zoœcia* distinctly tubular, with the ectocyst well developed, *statoblasts* of one kind only, each surrounded by a chitinous ring devoid of air-spaces, *polypides* with the lophophore circular or oval when expanded.

The Fredericellidæ consist of a single genus (*Fredericella*) which includes several closely-allied forms and has a wide geographical distribution

Genus FREDERICELLA, *Gervais* (1838)

Fredericella, Allman, Mon Fresh-Water Polyzoa, p 110 (1857)
Plumatella, ("arrêt de développement") Jullien, Bull Soc zool France, x, p 121 (1885)
Fredericella, Kraepelin, Deutsch Susswasserbryozoen, i, p. 99 (1887).
Fredericella, Goddard, Proc Linn Soc N S Wales, xxxiv, p 489 (1909)

This genus has the characters of the family. Its status has been much disputed, some authors regarding the shape of the lophophore as of great morphological importance, while Jullien believed that *Fredericella* was merely an abnormal or monstrous form of *Plumatella* The latter belief was doubtless due to the fact that the zoaria of the two genera bear a very close external resemblance to one another and are sometimes found entangled together The importance of the shape of the lophophore may, however, easily be exaggerated, for, as both Jullien and Goddard have pointed out, it assumes an emarginate form when retracted.

The best known species is the European and N. American *F. sultana* (Blumenbach), of which several varieties or phases have been described as distinct This form is stated to occur also in S Africa *F. australiensis*, Goddard* from N S Wales is said to differ from this species in having an oval instead of a circular lophophore and in other small anatomical characters, but it is doubtful how far these characters are valid, for the lophophore appears to be capable of changing its shape to some slight extent and has been stated by Jullien to be habitually oval in specimens from France *F cunningtoni*, Rousselet † from Lake Tanganyika has stout zoœcia encrusted with relatively large sand-grains

The zoaria of *Fredericella* are usually found attached to solid objects in shallow water, but a form described as *F duplessisi*, Ford has been found at a depth of 40 fathoms embedded in mud at the bottom of the Lake of Geneva. *F cunningtoni* was dredged from depths of about 10 and about 25 fathoms

The statoblasts of this genus do not float and often germinate in the parent zoœcium after its polypides have died They are produced in smaller numbers than is usually the case in other genera of the order The polypides sometimes undergo a process of regeneration, but without the formation of brown bodies

* Proc Linn Soc N S Wales, xxxiv, p 489 (1909)
† Rousselet, Proc Zool Soc London, 1907 (1), p 254

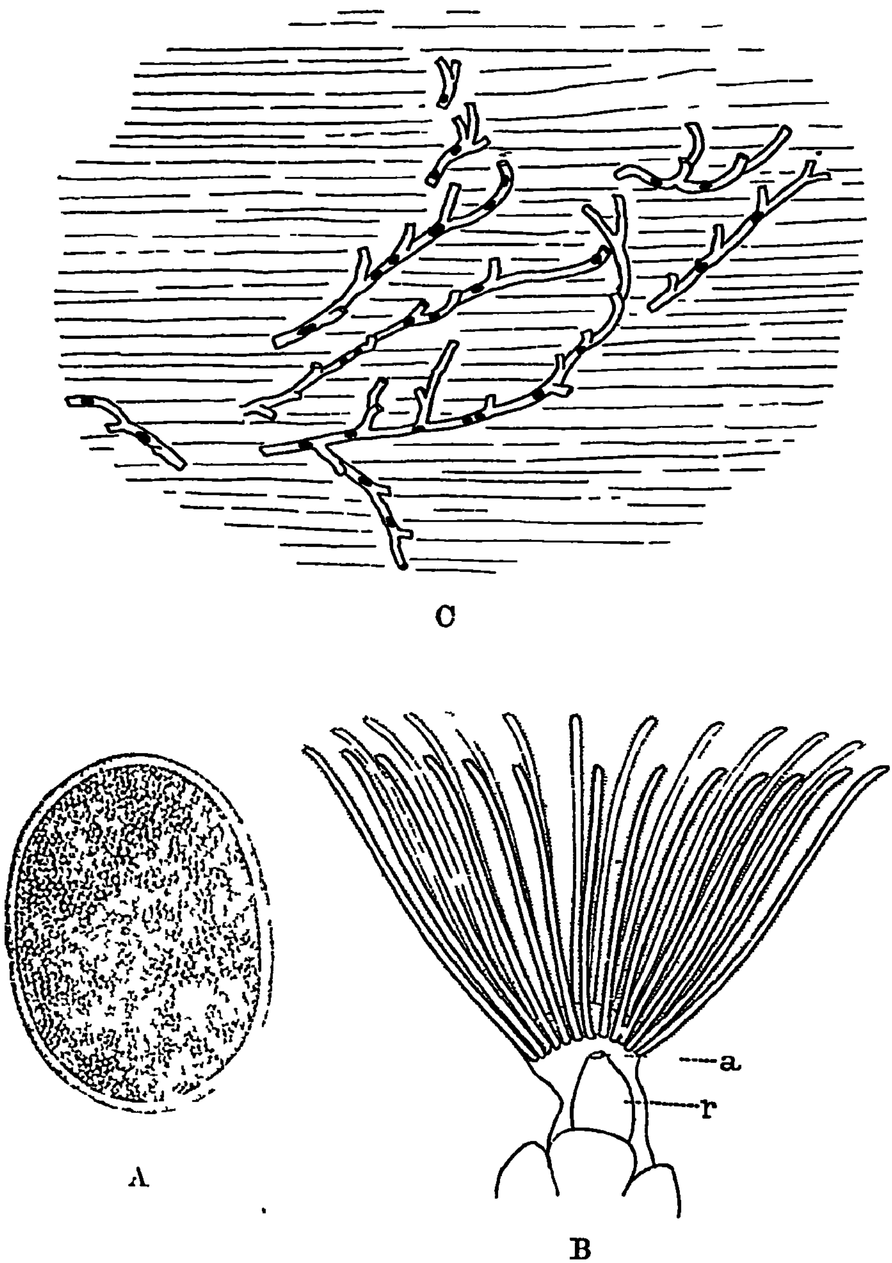


Fig 41 —*Fredericella indica*

A = statoblast, × 120 B = outline of expanded lophophore and adjacent parts, × 75, a = anus, r = rectum C = outline of zoarium on leaf of water-plant, × 3

(A and B are from specimens from Igatpuri, C from specimen from Shanthancottah)

28 Fredericella indica, *Annandale.*

Fredericella indica, Annandale, Rec Ind. Mus iii, p 373, fig (1909)
Fredericella indica, id, ibid v, p 39 (1910)

Zoarium The zoarium is of delicate appearance and branches sparingly It is often entirely recumbent but sometimes produces short, lax branches that consist of two or three zooecia only

Zooecia The zooecia are very slender and almost cylindrical, they are slightly emarginate and furrowed, the keel in which the furrow runs being sometimes prominent The external surface is minutely roughened and apparently soft, for small grains of sand and other débris cling to it, but never thickly The ectocyst is practically colourless but not transparent

Statoblasts The statoblasts are variable in size and form but most commonly have a regular broad oval outline; sometimes they are kidney-shaped The dorsal surface is covered with minute star-shaped prominences, which sometimes cover it almost uniformly and are sometimes more numerous in the centre than towards the periphery. The ventral surface is smooth

Polypide The lophophore bears about 20–25 tentacles, which are very slender and of moderate length, the velum at their base is narrow, as a rule the lophophore is accurately circular

TYPE in the Indian Museum

The most definite character in which this species differs from *F sultana* and *F australiensis* is the ornamentation of one surface of the statoblast, both surfaces of which are smooth in the two latter species From *F cunningtoni*, the statoblasts of which are unknown, it differs in having almost cylindrical instead of depressed zooecia and in not having the zooecia densely covered with sand-grains

GEOGRAPHICAL DISTRIBUTION.—Western India (the Malabar Zone) Igatpuri Lake, W Ghats (alt *ca* 2,000 feet), Bombay Presidency, and Shasthancottah Lake near Quilon, Travancore

BIOLOGY —In both the lakes in which the species has yet been found it was collected in November The specimens obtained in Travancore were found to be undergoing a process of regeneration due at least partly to the fact that most of the polypides had perished and that statoblasts were germinating in the old zooecia. Specimens from the Bombay Presidency, which were obtained a little later in the month, were in a more vigorous condition, although even they contained many young polypides that were not yet fully formed It seems, therefore, not improbable that *F indica* dies down at the beginning of the hot weather and is regenerated by the germination of its statoblasts at the beginning of the cold weather

At Shasthancottah zoaria were found entangled with zoaria of a delicate form of *Plumatella fruticosa* to which they bore a very close external resemblance.

Family 2. PLUMATELLIDÆ.

PLUMATELLIDÆ, Allman (*partim*), Mon Fresh-Water Polyzoa, pp 76, 81 (1857)

Phylactolæmata which have horseshoe-shaped lophophores and a well-developed ectocyst not specialized to form an organ of progression Some or all of the statoblasts are provided with a "swim-ring" consisting of symmetrically disposed, polygonal chitinous chambers containing air

It is convenient to divide the Plumatellidæ as thus defined into subfamilies (the Plumatellinæ and the Lophopinæ), which may be defined as follows —

Subfamily A. PLUMATELLINÆ

Zoarium dendritic or linear, firmly fixed to extraneous objects, zoœcia tubular, not fused together to form a gelatinous mass

Subfamily B LOPHOPINÆ

Zoarium forming a gelatinous mass in which the tubular nature of the zoœcia almost disappears, capable to a limited extent of progression along a smooth surface.

Both these subfamilies are represented in the Indian fauna, the Plumatellinæ by two of the three genera known to exist, and the Lophopinæ by two (or possibly three) of the four that have been described The following key includes all the known genera, but the names of those that have not been recorded from India are enclosed in square brackets

Key to the Genera of Plumatellidæ.

I Statoblasts without marginal processes
  A Zoœcia cylindrical, not embedded in a gelatinous investment (Plumatellinæ)
    a Zoœcia arising directly from one another, no stolon, free statoblast oval — PLUMATELLA, [p 212
    a'. Zoœcia arising singly or in groups from an adherent stolon, free statoblasts oval — STOLELLA, p 229
  B Zoœcia cylindrical, embedded in a structureless gelatinous investment
    Zoœcia arising from a ramifying stolon, statoblasts circular .. — [STEPHANELLA]
  C Polypides embedded in a hyaline synœcium that conceals the cylindrical form of the zoœcia (Lophopinæ)

c Polypides upright, their base far removed from that of the zoarium when they are expanded — LOPHOPUS, p 231

c' Polypides recumbent for the greater part of their length at the base of the zoarium — [AUSTRALELLA *]

II Statoblasts armed (normally) with hooked processes (Lophopinæ)

A Processes confined to the extremities of the statoblast, zoaria remaining separate throughout life — LOPHOPODELLA, [p 231

B Processes entirely surrounding the statoblast, many zoaria embedded in a common gelatinous investment so as to form large compound colonies — PECTINATELLA, [p 235

Subfamily A. PLUMATELLINÆ

Of the two Indian genera of this subfamily, one (*Plumatella*) is almost universally distributed, while the other (*Stolella*) has only been found in the valley of the Ganges The third genus of the subfamily (*Stephanella*) is only known from Japan

It should be noted that zoaria of different species and genera of this subfamily are often found in close proximity to one another and to zoaria of *Fredericella*, and that the branches of the different species are sometimes entangled together in such a way that they appear, unless carefully separated, to belong to the same zoarium.

Genus 1 PLUMATELLA, *Lamarck*

Plumatella, Lamarck, Animaux sans Vert (ed 1re) ii, p 106 (1816)
Alcyonella, id, ibid p 100
Plumatella, Allman, Mon Fresh-Water Polyzoa, p 92 (1857)
Alcyonella, id, ibid p 86
Plumatella, Hyatt, Comm Essex Inst iv, p 207, pl viii (1866)
Plumatella, Jullien (*partim*), Bull Soc zool France, x, p 100 (1885)
Hyalinella, id, ibid p 133
Plumatella, Kraepelin, Deutsch Susswasser Bryozoen, i, p 104 (1887)
Plumatella, Braem, Unter u Bryozoen des sussen Wassers, p 2 (Bibliotheca Zoologica, ii, 1890)

Zoarium dendritic, recumbent, erect, or partly recumbent and partly erect

Zoœcia tubular, not confined in a gelatinous syœcium, the ectocyst usually horny

Statoblasts often of two kinds, free and stationary, the latter without air-cells and as a rule adherent by one surface, the former provided with a well-developed ring of air-cells but without marginal processes, oval in form, never more than about 0 6 mm in length

Polypide with less than 65 tentacles

Certain forms of this genus are liable to become compacted

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* See Rec Ind Mus v, p 40, footnote (1910)

together in such a way as to constitute solid masses consisting of elongate vertical zooecia closely parallel to one another and sometimes agglutinated by means of a gummy substance These forms were given by Lamarck in 1816 the name *Alcyonella*, and there has been much dispute as to whether they represent a distinct genus, distinct species, or merely varieties or phases of

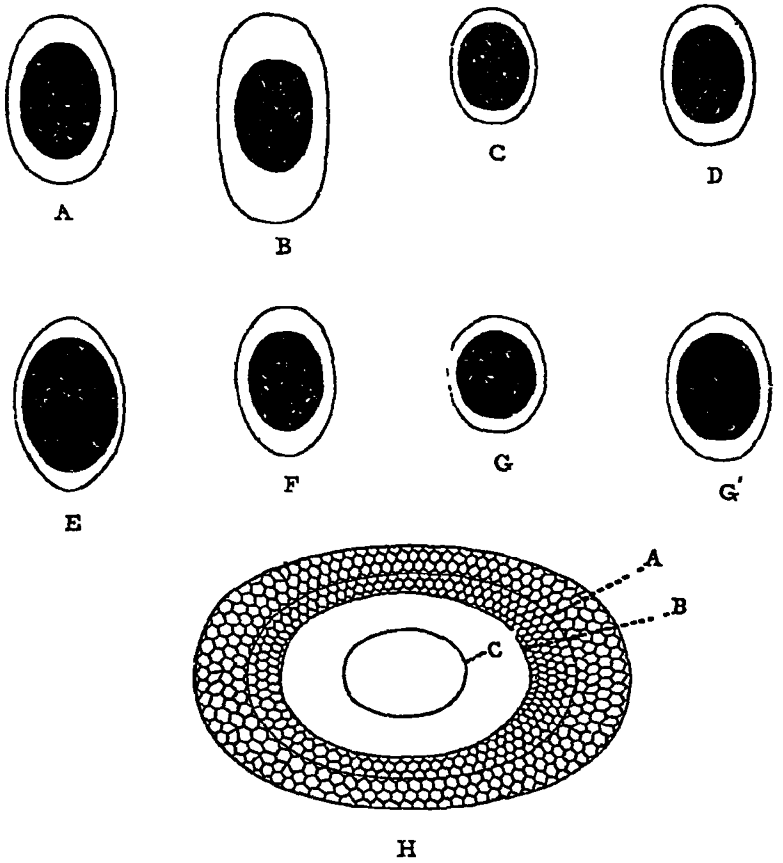

Fig 42 —Outlines of free statoblasts of *Plumatella* (enlarged).

A, of *P fruticosa* (Calcutta), B, of *P emarginata* (Calcutta), C, of *P javanica* (Travancore), D, of *P diffusa* (Sikhim), E, of *P allmani* (Bhim Tal), F, of *P diffusa* (Rajshahi, Bengal), G, G′, of *P punctata* (Calcutta), H, of *P diffusa* (Sikhim), statoblast further enlarged A=outline of capsule, B=limit of swim-ring on ventral surface, C=limit of swim-ring on dorsal surface [The dark area represents the capsule of the statoblast]

more typical forms It appears to be the case that all species which produce vertical branches are liable to have these branches closely packed together and the individual zooecia of which they are composed more or less greatly elongated It is in this way that the form known to Allman as *Alcyonella benedeni* is produced from the typical *Plumatella emarginata* Other forms go further and secrete a gummy substance that glues the upright zooecia

together and forces them to elongate themselves without branching. In these conditions the zoœcia become polygonal in cross-section It is probable that such forms (*e g*, *Plumatella fungosa* (Pallas)) should rank as distinct species, for the gummy secretion is present in great profusion even in young zoaria in which the zoœcia have not yet assumed a vertical position No such form, however, has as yet been found in India, and in any case it is impossible to regard *Alcyonella* as a distinct genus

Key to the Indian Species of Plumatella

I. Ectocyst more or less stiff, capable of transverse wrinkling only near the tips of the zoœcia, never contractile or greatly swollen zoœcia rounded* at the tip when the polypide is retracted Free statoblasts elongate, the free portion of their swim-ring distinctly narrower at the sides than at the ends
  - A Ectocyst by no means rigid, of a uniform pale colour, zoœcia never emarginate or furrowed, straight, curved or sinuous, elongate, cylindrical . . . *fruticosa*, p 217
  - B Ectocyst rigid, zoœcia (or at any rate some of the zoœcia) emarginate and furrowed
    - *b* Ectocyst darkly pigmented over the greater part of each zoœcium, white at the tip branching of the zoarium practically dichotomous, profuse, as a rule both horizontal and vertical, zoœcia straight or slightly curved or sinuous . . . *emarginata*, [p 220
    - *b'* Ectocyst colourless and hyaline, branching of the zoarium sparse, lateral, irregular, horizontal, zoœcia nearly straight, strongly emarginate and furrowed . . . *javanica*, p 221
    - *b''* The majority of the zoœcia distinctly L-shaped, one limb being as a rule adherent, ectocyst never densely pigmented
      - *β* *Zoœcia cylindrical, their furrowed keel never prominent* . . . *diffusa*, p 223
      - *β'* Zoœcia (or at any rate some of the zoœcia) constricted or tapering at the base, their emargination and furrow conspicuous . . . *allmani*, p 224

II Ectocyst stiff, zoœcia truncated when the polypide is retracted Surface of zoœcia minutely roughened, distinctly annulate on the distal part . . . *tanganyikæ*, [p 225

III Ectocyst swollen and contractile, capable of transverse wrinkling all over the zoœcium, zoœcia never emarginate. . . . . . *punctata*, p 227.

There has always been much difficulty in separating the species of *Plumatella*, and even now there is no general consensus of

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* In specimens preserved in spirit they are apt to collapse and therefore to become somewhat concave

opinion as to the number that should be recognized The difficulty, however, is much reduced if the following precautions are observed —

(1) If the zoarium appears to be tangled, if the branches intertwine or overlap, or if the zoœcia are closely pressed together, the whole mass should be carefully dissected out This is necessary not only because zoaria belonging to different species are sometimes found entangled together but also because it is often difficult to recognize the characteristic method of branching and shape of the zoœcia unless it is done

(2) As large a part as possible of each zoarium should be examined, preferably with a binocular microscope, and allowance should be made for irregularities and abnormalities of all kinds What must be observed is the rule rather than the exceptions.

(3) When the statoblasts are being examined, care must be taken that they lie flat and that their surface is parallel to that of the nose-piece of the microscope If they are viewed obliquely it is impossible to see their true outlines and proportions

(4) In order to see the relative proportions of the capsule and the swim-ring it is necessary that the statoblast should be rendered transparent This is often difficult owing to the presence of air in the air-cells, but strong nitric acid applied judiciously will render it possible (p. 240)

In supervising the preparation of the plates that illustrate this genus I have impressed upon the artist the importance of representing what he saw rather than what he thought he ought to see, and the figures are very close copies of actual specimens I have deliberately chosen for representation specimens of *Plumatella* preserved by the simple methods which are often the only ones that it is possible for a traveller to adopt, for the great majority of naturalists will probably have no opportunity of examining living specimens or specimens preserved by special methods, and the main object, I take it, of this series is to enable naturalists first to distinguish the species described and then to learn something of their habitat and habits.

Geographical Distribution —Of the seven species included in this key five have been found in Europe (namely *P. fruticosa*, *P emarginata*, *P diffusa*, *P allmani*, and *P punctata*), while of these five all but *P allmani* are known to occur in N America also. *P javanica* is apparently peculiar to the Oriental Region, while *P tanganyikæ* has only been taken in Central Africa and in the Bombay Presidency.

Types —Very few of the type-specimens of the older specie[illegible] *Plumatella* are in existence Allman's are neither in Edi[illegible] nor in London, and Mr. E Leonard Gill, who has b[illegible] enough to go through the Hancock Collection at Nev[illegible] Tyne, tells me that he cann[illegible] Hancock's. T[illegible]

forms described by Kraepelin are in Hamburg and that of *P. tanganyikæ* in the British Museum, and there are schizotypes or paratypes of this species and of *P javanica* in Calcutta The types of Leidy's species were at one time in the collection of the Philadelphia Academy of Science

BIOLOGY —The zoaria of the species of *Plumatella* are found firmly attached to stones, bricks, logs of wood, sticks, floating seeds, the stems and roots of water-plants, and occasionally to the shells of molluscs such as *Vivipara* and *Unio* Some species shun the light, but all are apparently confined to shallow water

Various small oligochæte worms (e g, *Chætogaster spongillæ*,* *Nais obtusa, Nais elinguis, Slavina appendiculata* and *Pristina longiseta* †), take shelter amongst them, dipterous larvæ of the genus *Chironomus* often build their protective tubes at the base of the zoaria, and the surface of the zoœcia commonly bears a more or less profuse growth of such protozoa as *Vorticella* and *Epistylis* I have seen a worm of the genus *Chætogaster* devouring the tentacles of a polypide that had been accidentally injured, but as a rule the movements of the lophophore are too quick to permit attacks of the kind, and I know of no active enemy of the genus The growth of sponges at the base of the zoaria probably chokes some species, but one form (*F fruticosa*) is able to surmount this difficulty by elongating its zoœcia (p 219) A small worm (*Aulophorus tonkinensis*) which is common in ponds in Burma and the east of India as far west as Lucknow, often builds the tube in which it lives mainly of the free statoblasts of this genus It apparently makes no selection in so doing but merely gathers the commonest and lightest objects it can find, for small seeds and minute fragments of wood as well as sponge gemmules and statoblasts of other genera are also collected by it I know of no better way of obtaining a general idea as to what sponges and phylactolæmata are present in a pond than to examine the tubes of *Aulophorus tonkinensis*

I am indebted to Mr F H Gravely, Assistant Superintendent in the Indian Museum, for an interesting note regarding the food of *Plumatella* His observations, which were made in Northamptonshire, were unfortunately interrupted at a critical moment, but I have reproduced them with his consent in order that other observers may investigate the phenomena he saw Mr Gravely noted that a small green flagellate which was abundant in water in which *Plumatella repens* was growing luxuriantly, was swallowed by the polypides, and that if the polyparium was kept in a shallow dish of water, living flagellata of the same species congregated in a little pile under the anus of each polypide His preparations show very clearly that the flagellates were passing through the alimentary canal without apparent change, but the method of

* Annandale, J As Soc Bengal (n s) ii, p 188, pl i (1906)
† See Michaelsen, Mem Ind Mus i, pp 131–135 (1908)

preservation does not permit the refractile granules, which were present in large numbers in the cell-substance of the flagellates, to be displayed and it is possible that these granules had disappeared from those flagellates which are present in the recta of his specimens It is clear, therefore, either that certain flagellates must pass through the alimentary canal of *Plumatella* unchanged, or that the polyzoon must have the power of absorbing the stored food material the flagellates contain without doing them any other injury.

The free statoblasts of *Plumatella* are as a rule set free before the cells they contain become differentiated, and float on the surface of the water for some time before they germinate, but occasionally a small polypide is formed inside the capsule while it is still in its parent zooecium I have, however, seen only one instance of this premature development, in a single statoblast contained in a small zoarium of *P. fruticosa* found in Lower Burma in March The fixed statoblasts usually remain fixed to the support of the zoarium, even when their parent-zooecium decays, and germinate *in situ*

The larva (fig 40 C, p 207) that originates from the egg of *Plumatella* is a minute pear-shaped, bladder-like body covered externally with fine vibratile threads (cilia) and having a pore at the narrow end At the period at which it is set free from the parent zooecium it already contains a fully formed polypide or pair of polypides with the tentacles directed towards the narrow end After a brief period of active life, during which it moves through the water by means of its cilia, it settles down on its broad end, which becomes adhesive, the polypide or pair of polypides is everted through the pore at the narrow end, the whole of this end is turned inside out, and a fresh polyparium is rapidly formed by budding

29 **Plumatella fruticosa**, *Allman* (Plate III, fig 1, plate IV, fig 4, plate V, fig. 1)

Plumatella fruticosa, Allman, Ann Nat Hist xiii, p 331 (1844)
Plumatella repens, van Beneden (? *nec* Linne), Mém Acad Roy Belg 1847, p 21, pl i, figs 1–4.
Plumatella fruticosa, Johnston, Brit Zooph (ed 2), p 404 (1847)
Plumatella coralloides, Allman, Rep Brit Assoc 1850, p 335
Plumatella stricta, *id*, Mon Fresh-Water Polyzoa, p 99, fig 14 (1857)
Plumatella fruticosa, *id* *ibid* p 102, pl vi, figs 3–5
Plumatella coralloides, *id*, *ibid* p 103, pl vii, figs 1–4
Plumatella repens and *P stricta*, Carter, Ann Nat Hist (3) iii, p 341 (1859)
Plumatella lucifuga, Julien (*partim*), Bull Soc zool France, x, p 114 (1885)
Plumatella princeps var *fruticosa*, Kraepelin, Deutsch. Susswasser-bryozoen, i, p 120, pl vii, fig 148 (1887)
Plumatella fruticosa, Braem, Unter u Bryozoen des sussen Wassers, p 9, pl i, fig 15 (Bibl Zool ii) (1890)
Plumatella repens, Annandale, J As Soc Bengal (new series) iii, 1907, p 88

Plumatella emarginata, Loppens (*partim*), Ann Biol Lacustre, iii, p 161 (1908)
Plumatella fruticosa, Annandale, Rec Ind Mus v, p 45 (1910)

Zoarium The zoarium in the typical form has a loose appearance due to the fact that the branches are far apart and the ectocyst by no means rigid When young the zoarium is adherent, but in well-grown polyparia vertical branches, often an inch or more in length, are freely produced As a rule they have not the strength to stand upright if removed from the water Branching is ordinarily lateral and as a rule occurs chiefly on one side of a main branch or trunk In certain circumstances upright zoœcia are pressed together and reach a great length without branching, and in this form (*P corallordes*, Allman) daughter-zoœcia are often produced at the tip of an elongated mother-zoœcium in fan-like formation A depauperated form (*P stricta*, Allman), occurs in which the vertical branches are absent or very short In all forms internal partitions are numerous and stout

Zoœcia The zoœcia are cylindrical and bear a simple keel on their dorsal surface They are never emarginate or furrowed. In the typical form their diameter is more than half a millimetre, and they are always of considerable length The ectocyst is thin and never very rigid or deeply pigmented, the colour usually being an almost uniform pale pinkish brown and fading little towards the tip of the zoœcium

Statoblasts Both free and stationary statoblasts are formed, but the latter are rare and do not always adhere They resemble the free statoblasts in general form but have a solid margin instead of a swim-ring and are often minutely serrated round the edge. The free statoblasts are at least considerably, sometimes very elongate; in all zoaria it is possible to find specimens that are more than twice as long as broad The capsule is relatively large and resembles the swim-ring in outline, so that the free portion of the latter is not much narrower at the sides than at the ends The sides are distinctly convex and the ends rounded, the swim-ring encroaches little on the surface of the capsule

Polypide The tentacles number between 40 and 50 and are not festooned at the base The stomach is slender and elongate

TYPE not in existence

SYSTEMATIC REMARKS —*P fruticosa* is closely allied to *P repens* (European and N American) but always has much longer statoblasts Three phases of the species may be distinguished as follows —

A (*Forma typica*) Zoœcia stout in form, not greatly elongate, free branches produced in profusion
B. (*P stricta*, Allman, *P. repens*, van Beneden) Zoœcia slender, free branches absent or consisting of two or three zoœcia only.
C (*P. coralloides*, Allman) Vertical zoœcia pressed together and greatly elongated

Indian specimens of the typical form agree well with German specimens labelled by Prof Kraepelin *P princeps* var *fruticosa*, and specimens of the *coralloides* phase could hardly be distinguished from similar specimens from Scotland

GEOGRAPHICAL DISTRIBUTION —*P fruticosa* is widely distributed in Europe and probably in N America I have seen Indian specimens from the Punjab (Lahore, *Stephenson*), from Bombay, from Travancore, from Calcutta and other places in the Ganges delta, from Rajshahi (Rampur Bhoolia) on the R Ganges, from Kurseong in the E Himalayas (alt 4,500 feet), and from Kawkareik in Tenasserim Statoblasts found on the surface of a pond near Simla in the W Himalayas (alt *ca* 8,000 feet), probably belong to this species

BIOLOGY —Allman states that in England *P fruticosa* is fond of still and slowly-running water The typical form and the *coralloides* phase grow abundantly in the Calcutta tanks, the former often attaining an extraordinary luxuriance I have found the var. *stricta* only in water in which there was reason to suspect a lack of minute life (and therefore of food), viz in Shasthancottah Lake in Travancore, in a swamp in Lower Burma, and in a small jungle stream near the base of the Western Ghats in Travancore The species is the only one that I have seen in running water in India, and the specimens obtained in the jungle stream in Travancore are the only specimens I have taken in these circumstances. *P. fruticosa* always grows near the surface or near the edge of water ; it is found attached to the stems of bulrushes and other aquatic plants, to floating seeds and logs and (rarely) to stones and bricks So far as my experience goes it is only found, at any rate in Calcutta, in the cold weather and does not make its appearance earlier than October

The form Allman called *P coralloides* was found by him, "attached to floating logs of wood together with *P repens* and *Cordylophora lacustris*, and generally immersed in masses of *Spongilla fluviatilis*' I have always found it immersed in sponges (*S lacustris*, *S alba*, *S carteri*, and *S crassissima*), except when the sponge in which it had been immersed had decayed Indeed, the peculiar form it has assumed appears to be directly due to the pressure of the growing sponge exerted on the zooecia, for it is often possible to find a zoarium that has been partially overgrown by a sponge and has retained its typical form so long as it was free but has assumed the *coralloides* form where immersed * In Shasthancottah Lake, Travancore, I found specimens of the *stricta* phase

* Braem (*op cit*, p 3, pl i, fig 1), has described and figured under the name *P fungosa* var *coralloides*, Allman, a dense form that somewhat resembles this phase of *P fruticosa* but has become compacted without external pressure It is, however, probably a form of *P repens* rather than *P fungosa* and differs in its broad statoblasts from any form of *P fruticosa* I have examined specimens of the same form from England

embedded in the gelatinous mass formed by a social rotifer and to some extent assimilated to the *coralloides* form

30 **Plumatella emarginata,** *Allman* (Plate III, fig 2, plate IV, figs 1, 1 *a*)

Plumatella emarginata, Allman, Ann Nat Hist xiii, p 330 (1844)
Plumatella emarginata, Johnston, Brit Zooph (ed 2), p 404 (1847)
Alcyonella benedeni, Allman, Mon Fresh-Water Polyzoa, p 89, pl iv, figs 5-11 (1857)
Plumatella emarginata, *id*, *ibid* p 104, pl vii, figs 5-10
Plumatella lucifuga, Jullien, Bull Soc Zool France, x, figs 89, 90, p 114 (1885)
Plumatella princeps var *emarginata*, Kraepelin (*partim*), Deutsch Susswasserbryoz p 120, pl iv, fig 108, pl v, fig 123 (1887)
Plumatella emarginata, Braem, Unter u Bryoz süssen Wassers, p 9, pl i, figs 12, 14 (Bibl Zool ii) (1890)
Plumatella emarginata, Annandale (*partim*), J As Soc Bengal, (new series) iii, 1907, p 89
Plumatella princeps, Loppens (*partim*), Ann Biol lacustre, iii, p 162, fig 7 (1908)
Plumatella emarginata, Annandale, Rec Ind Mus v, p 47 (1910)

Zoarium The zoarium often covers a considerable area on flat surfaces and is sometimes entirely recumbent More usually, however, the younger part is vertical In either case the branching is practically dichotomous, two young zoœcia arising almost simultaneously at the tip of a mother-zoœcium and diverging from one another at a small angle When the zoarium becomes vertical, rigid branches of as much as an inch in length are sometimes produced in this way and, arising parallel to one another, are pressed together to form an almost solid mass (=*Alcyonella benedeni*, Allman) In such cases the basal zoœcium or at any rate the basal part of each upright branch is considerably elongated. In recumbent zoœcia the main branches often radiate outwards from a common centre

Zoœcia The zoœcia are of almost equal width throughout, slender, and moderately elongate when recumbent Their ectocyst is stiff, they are emarginate at the tip and more or less distinctly furrowed on the dorsal surface, the keel in which the furrow runs not being prominent The orifice is often on the dorsal surface even in upright branches Each zoœcium is of a dark brown or almost black colour for the greater part of its length but has a conspicuous white tip which is extended down the dorsal surface in the form of a triangle, its limits being rather more extensive than and parallel to those of the emargination

Statoblast The majority of the free statoblasts are elongate and truncate or subtruncate at the extremities, the sides being as a rule straight and parallel In every polyparium specimens will be found that are between twice and thrice as long as broad The capsule is, however, relatively much broader than the swim-ring,

often being nearly circular, and there is therefore at either end a considerable extent of free air-cells, while the extent of these cells at the sides of the capsule is small The air-cells cover a considerable part of the dorsal surface of the capsule Fixed statoblasts are usually found in old colonies, especially at the approach of the hot weather They have an oval form and are surrounded by a membranous margin on which traces of reticulation can often be detected As a rule statoblasts of both types are produced in considerable but not in excessive numbers

Polypide There are about 40 tentacles, the velum at the base of which extends upwards for a considerable distance without being festooned The stomach is elongate and slender and narrowly rounded at the base

The method of branching, the coloration of the zoœcia and the form of the free statoblast are all characteristic Luxuriant or closely compressed zoaria of *P diffusa* often bear a superficial resemblance to those of *P emarginata*, but the resemblance disappears if they are carefully dissected out Indian ~~specimens~~ specimens of *P emarginata* agree closely with European ones

GEOGRAPHICAL DISTRIBUTION —*P emarginata* is a common species in Europe, N America, and southern Asia and probably also occurs in Africa and Australia I have examined specimens from Calcutta, Rangoon, and Mandalay in Indian territory, and also from Jalor in the Patani States (Malay Peninsula) and the Tale Noi, Lakon Sitamarat, Lower Siam Gemmules found by Apstein (Zool Jahrb (Syst) xxv, 1907, p 201) in plankton from the Colombo lake may belong to this species or to any of the others included by Kraepelin in his *P princeps*

BIOLOGY.—In Ireland Allan found *P emarginata* in streams and rivulets, but it also occurs in European lakes In India I have only found it in ponds It prefers to adhere to the surface of stones or bricks, but when these are not available is found on the stems of water-plants In the latter position the form called *Alcyonella benedeni* by Allman is usually produced, owing to the fact that the upright branches are crowded together through lack of space, very much in the same way (although owing to a different cause) as those of *P. fruticosa* are crowded together in the *coralloides* phase, to which the *benedeni* phase of *P emarginata* is in many respects analogous

Although it is essentially a cold-weather species in Calcutta, *P emarginata* is sometimes found in a living condition during the "rains." Zoaria examined at this season, however, contains few living polypides, the majority of the zoœcia having rotted away and left fixed statoblasts only to mark their former position

31 Plumatella javanica, *Kraepelin*

Plumatella javanica, Kraepelin, Mitt Nat Mus Hamb xxiii, p 143, figs 1–3 (1905)

Plumatella emarginata var *javanica*, Loppens, Ann Biol lacustre, iii, p 162 (1908)

Plumatella javanica, Annandale, Rec Ind Mus v, p 50 (1910)
Plumatella allmani var *dumortieri*, *id* (*partim*) (*nec* Allman), *ibid* p 49

This species is related to *P emarginata*, from which it may be distinguished by the following characters —

Zoarium. The zoarium is always entirely recumbent and branches sparingly, its method of branching does not approach the dichotomous type but is lateral and irregular Linear series of zooecia without lateral branches are often formed

Zooecia The zooecia are slender and often very long, they are strongly emarginate and furrowed, and the keel that contains the furrow is conspicuous The ectocyst is hyaline and as a rule absolutely colourless

Statoblasts. The free statoblasts are variable in length, sometimes distinctly elongate, sometimes elongate only to a moderate degree; they are rounded at the extremities and have the sides slightly or distinctly convex outwards The capsule is relatively large, and the free portion of the swim-ring is not much broader at the ends than at the sides. The fixed statoblasts are elongate and surrounded by an irregularly shaped chitinous membrane, which is often of considerable extent The whole of the dorsal surface is covered with what appear to be rudimentary air-spaces some of which even contain air

The transparent glassy ectocyst and strong furrowed keel of this species are very characteristic, but the former character is apt to be obscured by staining due to external causes, especially when the zoarium is attached to dead wood The shape of the free statoblasts is too variable to be regarded as a good diagnostic character, but the fixed statoblasts, when they are to be found, are very characteristic in appearance *P javanica* appears to be closely related to Allman's *P dumortieri*, with which stained zoaria are apt to be confused The character of the ectocyst is, however, different, and the free part of the swim-ring is distinctly narrower at the sides of the free statoblasts. Dr. Kraepelin has been kind enough to send me one of the types

Types in the Hamburg and Indian Museums

Geographical Distribution —Java, Penang, India Indian localities are —Bengal, Calcutta, Berhampore, Murshidabad, R Jharai, Siripur, Saran district, Tirhut E Himalayas, Kurseong, Darjiling district (alt 4,500 feet) Madras Presidency, canal near Srayikaad, Travancore Mr. C W Beebe has recently sent me a specimen taken by him in the Botanical Gardens at Penang

Biology —Very little is known about the biology of this species Kraepelin took it in Java on the leaves of water-lilies It is not uncommon during the cold weather in the Calcutta Zoological Gardens on floating seeds and sticks and on the stems of bulrushes, in Travancore I took it in November on the submerged leaves of *Pandani* growing at the edge of a canal of

slightly brackish water Mr Hodgart, the collector of the Indian Museum, found it in the R Jharai on the stems of water-plants at a time of flood in the "rains" In Calcutta it is often found entangled with *P fruticosa* and *P emarginata*

32 **Plumatella diffusa**, *Leidy*. (Plate IV, fig 2)

Plumatella diffusa, Leidy, P Ac Philad v, p 261 (1852)
Plumatella diffusa, Allman, Mon Fresh-Water Polyzoa, p 105 (1857)
Plumatella diffusa, Hyatt, Comm Essex Inst iv, pl viii, figs 11, 12 (1866)
Plumatella diffusa, *id*, *ibid* v, p 107, fig 12 (1868)
Plumatella repens, Jullien, Bull Soc zool France, x, fig 37 (*lapsus* for 73), p 110 (1885)
Plumatella diffusa, *id*, *ibid* figs 155, 157, pp 130, 131
Plumatella allmani var *diffusa*, Annandale, Rec Ind Mus v, p 49 (1910)

Zoarium The zoarium often covers a considerable area on flat surfaces and is sometimes found crowded together on the stems of plants In the latter case the arrangement of the main branches is distinctly radiate Upright branches occur rarely and never consist of more than three zoœcia The characteristic method of branching is best represented by the following diagram —

Fig 43

The partitions are stout and numerous

Zoœcia The great majority of the zoœcia in each zoarium are distinctly L-shaped, the long limb being usually adherent The vital organs of the polypide are contained in the vertical limb, while the horizontal one, in mature polyparia, is packed full of free statoblasts The zoœcia are cylindrical and as a rule obscurely emarginate and furrowed The ectocyst is stiff; it is never deeply pigmented but is usually of a transparent horn-colour at the base of each zoœcium and colourless at the tip, the contrast between the two portions never being very strong The basal portion is rough on the surface, the distal portion smooth.

Statoblasts Free statoblasts are produced in very great profusion and fixed statoblasts are also to be found as a rule. The latter resemble those of *P emarginata* The free statoblasts are never very large or relatively broad, but they vary considerably as regards size and outline The capsule is large, the sides convex outwards and the extremity more or less broadly rounded The air-cells are unusually large and extend over a great part of the dorsal surface of the statoblast.

Polypide The polypide is shorter and stouter than that of *P. emarginata* and as a rule has fewer tentacles

The most characteristic feature of this species is the form of the zoœcia, which differ greatly from those of any other Indian species but *P allmani* In the latter they are distinctly "keg-shaped" (*i e*, constricted at the base and swollen in the middle), and the zoarium never spreads out over large surfaces in the way in which that of *P diffusa* does

TYPE—? in the Philadelphia Academy of Sciences

GEOGRAPHICAL DISTRIBUTION—This species was originally described from North America (in which it is apparently common) and occurs also in Europe I have seen Indian specimens from the following localities —BENGAL, Calcutta and neighbourhood, Rajshahi (Rampur Bhulia) E HIMALAYAS, Gangtok, Native Sikhim (alt 6,150 feet) (*Kirkpatrick*, *Stewart*) PUNJAB, Lahore (*Stephenson*)

BIOLOGY—*P diffusa* in Lower Bengal is a cold-weather species It is remarkable for the enormous number of gemmules it produces and is usually found either on floating objects such as the stems of certain water-plants, or on stones or bricks at the edge of ponds

33 **Plumatella allmani**, *Hancock* (Plate IV, figs 3, 3*a*)

Plumatella allmani, Hancock, Ann Nat Hist (2) v, p 200, pl v, fig 3–4, pl iii, fig 2–3 (1850)
Plumatella allmani, Allman, Mon Fresh-Water Polyzoa, p 106, fig 16 (1857)
Plumatella elegans, *id*, *ibid* p 107, pl viii, figs 6–10
Plumatella lucifuga ("forme rampante") Jullien, Bull Soc zool France, x, p 114 (1885)

This species is closely allied to *P diffusa*, from which it differs in the following characters.—

(1) The zoarium never covers a large area and as a rule grows sparingly and mainly in two directions
(2) The zoœcia are more irregular in shape, not so distinctly elbowed, smaller; they have a much more prominently keeled ridge The great majority of them are constricted at the base and taper towards the orifice. In young zoaria they are almost colourless but in older ones there is a band of not very dense pigment round the base of the vertical limb
(3) The free statoblasts are comparatively large and usually show a tendency to taper at the extremities, often being almost rhomboidal in form The swim-ring does not extend so far over the dorsal surface as it does in those of *P diffusa*, the "cells" of which it is composed are small

TYPE not in existence

I have seen every gradation between this form and Allman's *P elegans*.

GEOGRAPHICAL DISTRIBUTION —*P allmani* is apparently a rare species to which there are few references in literature. It was originally described from England and is stated by Jullien to occur in France I have found specimens only in the lake Bhim Tal (alt 4,500 feet) in the W Himalayas

BIOLOGY —The original specimens were found by Hancock on stones My own were growing on the leaves of water-plants, usually on the under side When the zoœcia were forced to stretch across from one leaflet to another they assumed the sinuous form characteristic of Allman s *P elegans*

34 **Plumatella tanganyikæ**, *Rousselet*

Plumatella tanganyikæ, Rousselet, Proc Zool Soc London, 1907 (i), p 252, pl xiv, figs 1–4

Plumatella bombayensis, Annandale, Rec Ind Mus ii, p 169, figs 1, 2 (1908)

Plumatella bombayensis, *id*, *ibid* v, p 51 (1910)

Zoarium The whole colony is recumbent but branches freely and at short intervals in a horizontal plane, so that the zoœcia become crowded together and the branches sometimes overlap one another The zoarium often covers a considerable area, but growth seems to be mainly in two directions When growing on the stems of water-plants the branches are often parallel and closely pressed together but remain recumbent in this position A stout membrane sometimes extends between branches and individual zoœcia

Zoœcia The walls of the zoœcia are thick, stiff, and more or less darkly but not opaquely pigmented, the external surface, although not very smooth, is always clean The two most noteworthy characters of the zoœcia are (i) their truncated appearance when the polypide is retracted, and (ii) the conspicuous, although often irregular external annulation of their walls The tip of each zoœcium, owing to the fact that the invaginated part of the ectocyst is soft and sharply separated from the stiffened wall of the tube, terminates abruptly and is not rounded off gradually as is the case in most species of the genus, sometimes it expands into a trumpet-like mouth The annulation of the external surface is due to numerous thickened areas of the ectocyst which take the form of slender rings surrounding the zoœcium, they are most conspicuous on its distal half On the dorsal surface of the base of each zoœcium there is a conspicuous furrowed keel, which, however, does not usually extend to the distal end, the latter is oval in cross-section The zoœcia are short and broad, their base is always recumbent, and, when the zoarium is attached to a stone or shell, often seems to be actually embedded in the support, the distal part turns upwards and is free, so that the aperture is terminal, the zoœcia of the older parts of the zoarium

exhibit the specific characters much more clearly than those at the growing points.

Polypide. The lophophore bears 20 to 30 tentacles, which are long and slender, the velum at their base extends up each tentacle in the form of a sharply pointed projection, but these projections do not extend for more than one-fifth of the length of the tentacles Both the velum and the tentacular sheath bear numerous

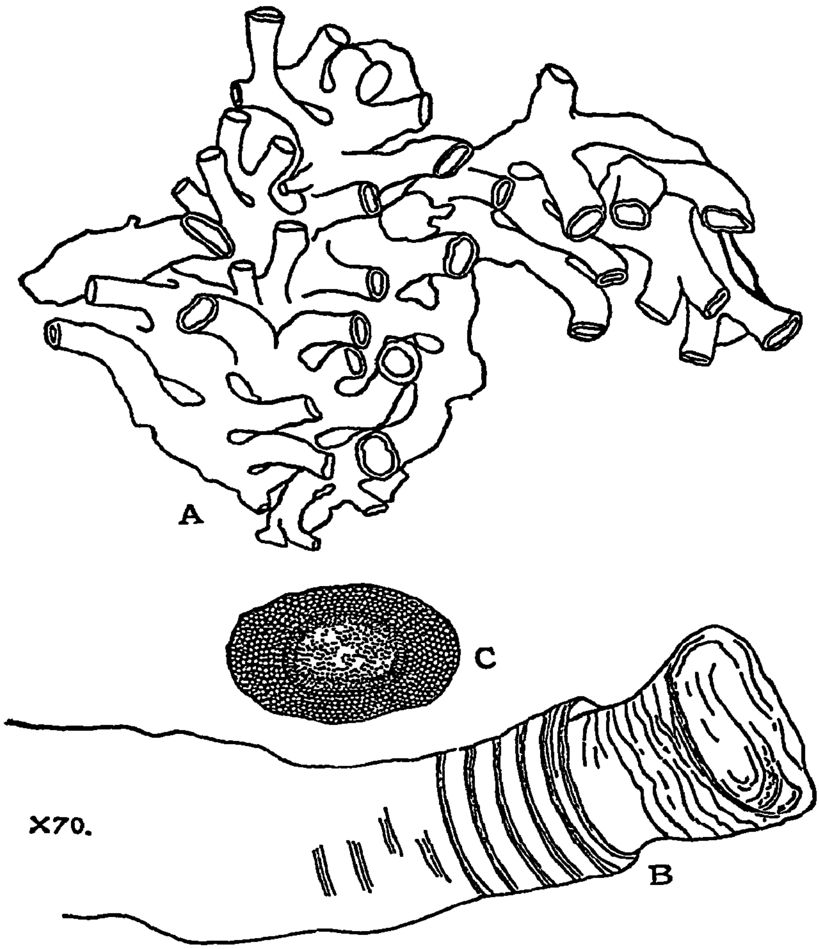

Fig 44 —*Plumatella tanganyikæ* from Igatpuri Lake
A=outline of part of zoarium from a stone, × 16, B=outline of the tip of a single zoœcium, × 70, C=free statoblast, × 70

minute tubercles on the external surface The base of the stomach is rounded, and the whole of the alimentary canal has a stout appearance

Statoblasts Both fixed and free statoblasts are produced, but not in very large numbers The latter are broadly oval and are surrounded by a stout chitinous ring, which often possesses irregular membranous projections, the surface is smooth The free statoblasts are small and moderately elongate, the maximum breadth as a rule measuring about $\frac{2}{3}$ of the length; the capsule is relatively large and the ring of air-cells is not very much broader at the ends than at the sides, the dorsal surface of the central capsule is profusely tuberculate The outline of the whole structure is often somewhat irregular

In deference to Mr Rousselet's opinion expressed in a letter I have hitherto regarded the Bombay form of this species as distinct from the African one, and there certainly is a great difference in the appearance of specimens taken on the lower surface of stones in Igatpuri Lake and of the types of *P tanganyikæ*, one of which is now in the collection of the Indian Museum The dark colour of the former, however, and their vigorous growth appear to be directly due to environment, for these characters disappear to a large extent in specimens growing on the stems of water-plants in the same lake Indeed, such specimens are exactly intermediate between the form "*bombayensis*" and the typical form of the species *P tanganyikæ* is closely allied to *P philippinensis*, Kraepelin, from the island of Luzon, but the latter has a smooth and polished ectocyst devoid of annulations, and zoœcia of a more elongate and regular form

TYPES of the species in the British and Indian Museums, those of *P bombayensis* in the latter collection

GEOGRAPHICAL DISTRIBUTION.—*P. tanganyikæ* is only known as yet from L Tanganyika in Central Africa and from Igatpuri in the Bombay Presidency.

BIOLOGY —In both localities the zoaria were found in shallow water In L Tanganyika they were encrusting stones and shells, while at Igatpuri they were fixed for the most part to the lower surface of stones but were also found on the stems of water-plants. My specimens from the Bombay Presidency were taken, on two separate occasions, at the end of November At that date the zoaria were already decaying and large blanks, marked out by fixed statoblasts, were often observed on the stones Probably, therefore, the species flourishes during the "rains"

35 **Plumatella punctata**, *Hancock* (Plate IV, fig 5)

Plumatella punctata, Hancock, Ann Nat Hist (2) x, p 200, pl iii fig 1, and pl x, figs 6, 7 (1850)
Plumatella vesicularis, Leidy, P Ac Philad vii, p 192 (1854)
Plumatella vitrea, Hyatt, Comm Essex Inst iv, pl ix, figs 1, 2 (1866)
Plumatella punctata, Allman, Mon Fresh-Water Polyzoa, p 100, fig 15 (1857)
Plumatella vesicularis, *id*, *ibid* p 101

Plumatella vitrea, Hyatt, Proc Essex Inst v, p 225, figs 18, 19 (1868)
Plumatella vesicularis, id, ibid p 225
Hyalinella vesicularis, Jullien, Bull Soc zool France, x, p 133, figs 165–172 (1885)
Hyalinella vitrea, id, ibid p 134, figs 173–179
Plumatella punctata, Kraepelin, Deutsch Susswasserbryozoen, i, p 126, pl iv, figs 115, 116, pl v, figs 124, 125, pl vii, figs 153, 154 (1887).
Plumatella vesicularis, Braem, Unters u Bryozoen sussen Wassers, p 8, pl i, fig 8 (Bibl Zool ii) (1890)
Hyalinella punctata, Loppens, Ann Biol lacustre, iii, p 163 (1908)
Plumatella punctata, Annandale, Rec Ind Mus v, p 52 (1910)

Zoarium The zoarium is entirely recumbent and often appears to form an almost uniform flat layer instead of a dendritic body Sometimes, however, it is distinctly linear, with lateral branches produced irregularly at considerable distances apart

Zoœcia. The zoœcia differ from those of all other species in having a greatly swollen, soft ectocyst which can be transversely wrinkled all over the zoœcium by the action of the muscles of the polypide and is distinctly contractile It is mainly owing to the swollen and almost gelatinous nature of the ectocyst that the dendritic character of the zoarium is frequently concealed, for the method of branching is essentially the same as that of *P diffusa*, although the zoœcia are not so distinctly elbowed The ectocyst is colourless or faintly tinted with brown, as a rule it is not quite hyaline and the external surface is minutely roughened or tuberculate The zoœcia are not emarginate or furrowed

Statoblasts Stationary statoblasts are not found The free statoblasts are variable and often asymmetrical in outline, but the free portion of the swim-ring is always of nearly equal diameter all round the periphery and the capsule relatively large Some of the statoblasts are always broad in comparison with their length

Polypide The polypide is comparatively short and stout European specimens are said to have from 30 to 40 tentacles, but Indian specimens have only from 20 to 30

Shrunken specimens of the less congested forms of this species closely resemble specimens of *P repens*, but the statoblasts are more variable in shape and the ectocyst, even in such specimens, is thicker Living or well-preserved specimens cannot be mistaken for those of any other species Jullien regarded *P punctata* as the type of a distinct genus (*Hyalinella*) but included in *Plumatella* at least one form (*P* "*arethusa*") which probably belongs to this species Kraepelin distinguishes as "varieties" two phases, a summer phase ("var *prostrata*") and an autumn phase ("var *densa*") The former often forms linear series of considerable length with only an occasional side-branch, while in the autumn phase branching is so profuse and the branches are so closely pressed together that the zoarium comes to resemble a uniform gelatinous patch rather than a dendritic growth A

phase resembling the European autumn form is the commonest in Calcutta and I have also found one intermediate between this and Kraepelin's "var *prostrata*," neither having any seasonal significance in India

GEOGRAPHICAL DISTRIBUTION —*P punctata* is widely distributed in Europe and N America, but in the Oriental Region it has only been found in Calcutta and the neighbourhood

BIOLOGY —In this part of India *P punctata* flourishes both during the "rains" and in winter I have found specimens in June and July and also in December and January The majority of them were attached to bricks, but some were on the roots of duckweed, the stems of water-plants, and the tips of creepers falling into water The species is often found together with *Stolella indica* and also with other species of its own genus It is most common, in the neighbourhood of Calcutta, in that part of the town which is near the Salt Lakes, and occurs in ponds the water of which is slightly brackish.

Genus 2 STOLELLA, *Annandale*

Stolella, Annandale, Rec. Ind Mus iii, p 279 (1909)
Stolella, *id*, *ibid* v, p 53 (1910)

TYPE, *Stolella indica*, Annandale.

Zoarium The zoarium consists of groups of zooecia (or occasionally of single zooecia) joined together by an adherent rhizome There is no gelatinous investment

Zooecia The adult zooecia resemble those of *Plumatella* except in being sometimes more or less upright

Polypide and *Statoblasts*. The polypide and statoblasts resemble those of *Plumatella* Fixed as well as free statoblasts occur

This genus is closely allied to *Plumatella*, from which it is probably derived. The root-like tube from which the zooecia arise is formed by the great elongation of the basal part of a zooecium, and the zoaria closely resemble those of *P. punctata*, for it is not until several zooecia have been produced that the characteristic mode of growth becomes apparent

Stolella has only been found in India and is monotypic *

36 Stolella indica, *Annandale* (Plate V, figs 3, 4.)

Stolella indica, Annandale, Rec Ind Mus iii, p 279, fig. (1909)
Stolella indica, *id*, *ibid* v, p 53 (1910)

Zoarium The zoarium is adherent and linear, having neither lateral nor vertical branches

* But see p 246 (addenda)

Zoœcia. The zoœcia are short and slendei, erect or nearly so, distinctly emarginate and furrowed Their ectocyst is soft, colourless and transparent but minutely roughened on the surface

Polypide The tentacles number from 30 to 35 and are rather short and stout, sometimes being slightly expanded at the tips The stomach is comparatively short and abruptly truncated posteriorly

Statoblasts Both free and fixed statoblasts are found, and both are variable in form, the latter varying in outline from the circular to the broadly oval. The free statoblasts resemble those of *Plumatella punctata*, but are sometimes rather more elongate

TYPE in the Indian Museum

Fig 45 —Zoarium of *Stolella indica* on stem of water-plant (from Calcutta), × 6

GEOGRAPHICAL DISTRIBUTION —So far as we know, this species is confined to the Indo-Gangetic Plain Major Walton found it at Bulandshahr in the United Provinces, and it is not uncommon in the neighbourhood of Calcutta

BIOLOGY —The zoaria of *S indica* are usually fixed to the roots ot duckweed oi to the stems ot other plants They are often found together with those of *P punctata* A slight infusion of brackish water into the ponds in which it lives does not seem to be inimical to this species, but I have found it in ponds in which nothing of the kind was possible It flourishes during the "rains" and, to judge from specimens kept in an aquarium, is very short-lived Major Walton found it growing over a zoarium of *Hislopia lacustris*

Subfamily B. LOPHOPINÆ

The zoaria of this subfamily are never dendritic but form gelatinous masses which, except in *Australella*, are cushion-shaped or sack-like With the possible exception of *Australella*, they possess to a limited extent the power of moving along vertical or horizontal surfaces, but it is by no means clear how they do so (see p 172) The statoblasts are remarkable for their large size. and it is noteworthy that *Australella*, which is intermediate in structure between the Plumatellinæ and the Lophopinæ, possesses statoblasts of intermediate size The swim-ring is always well developed, and fixed statoblasts are unknown

Only two genera (*Lophopodella* and *Pectinatella*) have been definitely proved to occur in India, but a third (*Lophopus* *) is stated to have been found in Madras. Should it be met with it will easily be recognized by the upright position of its polypides when their tentacles are expanded and by the fact that the statoblasts never bear marginal processes

Genus 3 LOPHOPODELLA, *Rousselet.*

Lophopodella, Rousselet, Journ Quek Micr Club (2) ix, p 45 (1904)

Lophopodella, Annandale, Rec Ind Mus v, p 54 (1910)

TYPE, *Pectinatella carteri*, Hyatt

Zoarium The zoarium consists of a circular or oval mass of no great size Polyparia do not form compound colonies

Polypides. The polypides lie semi-recumbent in the mass and never stand upright in a vertical position

Statoblasts The statoblasts are of considerable size and normally bear at both ends a series of chitinous processes armed with double rows of small curved spinules

As a rule the genus is easily recognized by means of the statoblasts, but sometimes the processes at the ends of these structures are absent or abortive and it is then difficult to distinguish them from those of *Lophopus* There is, however, no species of that

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* Only two species are known, *L crystallinus* (Pallas) from Europe and N America, with oval statoblasts that are produced and pointed at the two ends, and *L jheringi*, Meissner from Brazil, with irregularly polygonal or nearly circular statoblasts

genus known that has statoblasts shaped like those of the Indian species of *Lophopodella*

Three species of *Lophopodella*, all of which occur in Africa, have been described, *L capensis* from S Africa, which has the ends of the statoblast greatly produced, *L thomasi* from Rhodesia, in which they are distinctly concave, and *L carteri* from E Africa, India and Japan, in which they are convex or truncate

The germination of the gemmule and the early stages in the development of the polyparium of *L capensis* have been described by Miss Sollas (Ann Nat Hist (8) ii, p 264, 1908)

37 **Lophopodella carteri** (*Hyatt*) (Plate III, figs. 4, 4*a*)

Lophopus sp, Carter, Ann Nat Hist (3) iii, p 335, pl viii, figs 8-15 (1859)
? *Lophopus* sp, Mitchell, Q J Micr Sci London (3) ii, p 61 (1862)
Pectinatella carteri, Hyatt, Comm Essex Inst ix, p 203 (footnote) (1866)
Pectinatella carteri, Meissner, Die Moosthiere Ost-Afrikas, p 4 (in Mobius's Deutsch-Ost-Afrika, iv, 1898)
Lophopodella carteri, Rousselet, Journ Quek Micr Club, (2) ix, p 47, pl iii, figs 6, 7 (1904)
Lophopus carteri, Annandale, Rec Ind Mus ii, p. 171, fig 3 (1908)
Lophopodella carteri, *id*, *ibid* v, p 55 (1910)

Zoarium The zoarium as a rule has one horizontal axis longer than the other so that it assumes an oval form when the polypides are expanded, when they are retracted its outline is distinctly lobular Viewed from the side it is mound-shaped The polypides radiate, as a rule in several circles, from a common centre The ectocyst is much swollen, hyaline and colourless.

Polypide. The polypide has normally about 60 tentacles, the velum at the base of which is narrow and by no means strongly festooned The stomach is yellow or greenish in colour. The extended part of the polypide measures when fully expanded rather less than 3 mm, and each limb of the lophophore about the same

Statoblast The statoblast is variable in shape and size but measures on an average about 0 85×0 56 mm The ends are truncate or subtruncate, the capsule is small as compared with the swim-ring and as a rule circular or nearly so The processes at the two ends are variable in number, so also are their spinules, which are arranged in two parallel rows, one row on each side of the process, and are neither very numerous nor set close together, as a rule they curve round through the greater part of a circle and are absent from the basal part of the process

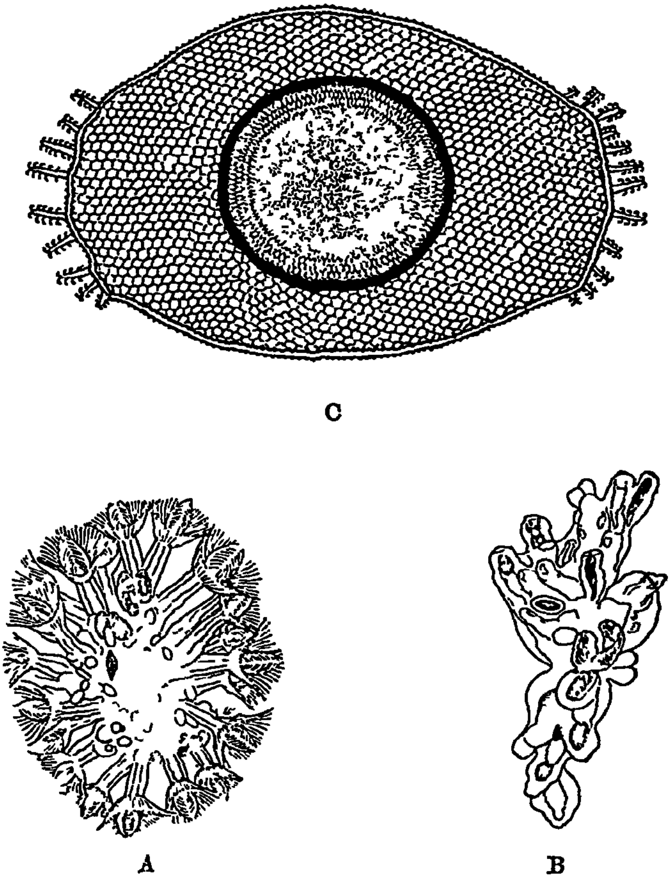


Fig 46.—*Lophopodella carteri* (from Igatpuri Lake)

A = outline of a zoarium with the polypides expanded, as seen from below through glass to which it was attached, ×4, B = outline of a zoarium with the polypides highly contracted, as seen from above, ×4, C = statoblast, ×75

37 *a* Var himalayana

Lophopus lendenfeldi, Annandale (*nec* Ridley), J As Soc Bengal, (n s) iii, 1907, p 92, pl ii, figs 1-4 (1907)
Lophopus lendenfeldi var *himalayanus*, *id*, Rec Ind Mus i, p 147, figs 1, 2 (1907)
Lophopus himalayanus, *id*, *ibid* ii, p 172, fig 4 (1908).

This variety differs from the typical form in having fewer tentacles and in the fact that the marginal processes of the statoblast are abortive or absent

Pectinatella davenporti, Oka * from Japan is evidently a local race of *L carteri*, from the typical form of which it differs in having the marginal processes of the statoblast more numerous and better developed The abortive structure of these processes in var *himalayana* points to an arrest of development, for they are the last part of the statoblast to be formed

TYPES The statoblasts mounted in Canada balsam by Carter and now in the British Museum must be regarded as the types of the species named but not seen by Hyatt The types of the var. *himalayana* are in the Indian Museum and those of the subspecies *davenporti* presumably in the possession of Dr Oka in Tokyo

GEOGRAPHICAL DISTRIBUTION —The typical form occurs in Bombay, the W Himalayas and possibly Madras, and its statoblasts have been found in E Africa, the var *himalayana* has only been taken in the W Himalayas and the subspecies *davenporti* in Japan Indian localities are —BOMBAY PRESIDENCY, Igatpuri Lake, W Ghats (alt *ca* 2,000 feet), the Island of Bombay (*Carter*) W HIMALAYAS, Bhim Tal, Kumaon (alt 4,500 feet)

BIOLOGY —*L carteri* is found on the lower surface of stones and on the stems and leaves of water-plants, usually in lakes or large ponds Although the zoaria do not form compound colonies by secreting a common membrane or investment, they are markedly gregarious The most closely congregated and the largest zoaria I have seen were assembled amongst a gelatinous green alga of the genus *Tolypothrix* † (Myxophyceæ) that grows on the vertical stems of a plant at the edge of Igatpuri Lake, it is noteworthy that in this case the alga seemed to take the place of the common investment of *Pectinatella burmanica*, in which green cells are present in large numbers (p 237) The zoaria of *L carteri* are able to change their position, and I found that if a number of them were placed in a bottle of water they slowly came together at one spot, thus apparently forming temporary compound colonies Before a movement of the whole zoarium commences its base becomes detached from its support at the anterior end (fig 32, p. 172), but the whole action is extremely slow and I have not been able to discover any facts that cast light on its exact method of production At Igatpuri statoblasts are being produced in considerable numbers at the end of November, but many young zoaria can be found in which none have as yet been formed

The larva of a fly of the genus *Chironomus* is often found inhabiting a tube below zoaria of *L carteri* It is thus protected from its enemies but can protrude its head from beneath the zoarium and seize the small animals on which it preys

* Zool Anz xxxi, p 716 (1907), and Annot Zool Japon vi, p 117 (1907)

† Prof W West will shortly describe this alga, which represents a new species, in the Journ Asiat Soc Bengal, under the name *Tolypothrix lophopodellophila* —April 1911

Genus 4 PECTINATELLA, *Leidy*

Cristatella, Leidy, P Ac Philad v, p 265 (1852)
Pectinatella, *id*, *ibid*, p 320
Pectinatella, Allman, Mon Fresh-Water Polyzoa, p 81 (1857)
Pectinatella, Hyatt, Proc Essex Inst v, p 227, fig 20 (1867)
Pectinatella, Kraepelin, Deutsch Susswasserbryozoen, i, p 133 (1887)
Pectinatella, Oka, Journ Coll Sci Tokyo, iv, p 89 (1891)

TYPE, *Pectinatella magnifica*, Leidy

This genus is closely allied to *Lophopodella*, from which it is often difficult to distinguish young specimens Adult zoaria are, however, always embedded together in groups in a gelatinous investment which they are thought to secrete in common*, and the statoblasts are entirely surrounded by processes that bear curved spinules at their tips only The polypides have the same semi-recumbent position as those of *Lophopodella* but are larger than those of any species of *Lophopodella* or *Lophopus* yet known The statoblasts are larger than those of any other Plumatellidæ

The type-species was originally found in N America but has since been taken in several localities in continental Europe Except this and the Indian form only one species is known, namely *P gelatinosa* from Japan *P magnifica* has circular statoblasts with long marginal processes, while in *P gelatinosa* the statoblasts are subquadrate and in *P burmanica* almost circular, both Asiatic forms having very short marginal processes

The compound colonies formed by *Pectinatella* are often of great size Those of *P gelatinosa* are sometimes over 2 metres in length, while those of *P burmanica* in the Sur Lake appeared to be only limited as regards their growth by the shallowness of the water in which the reeds to which they were attached were growing Some were observed that were over 2 feet long

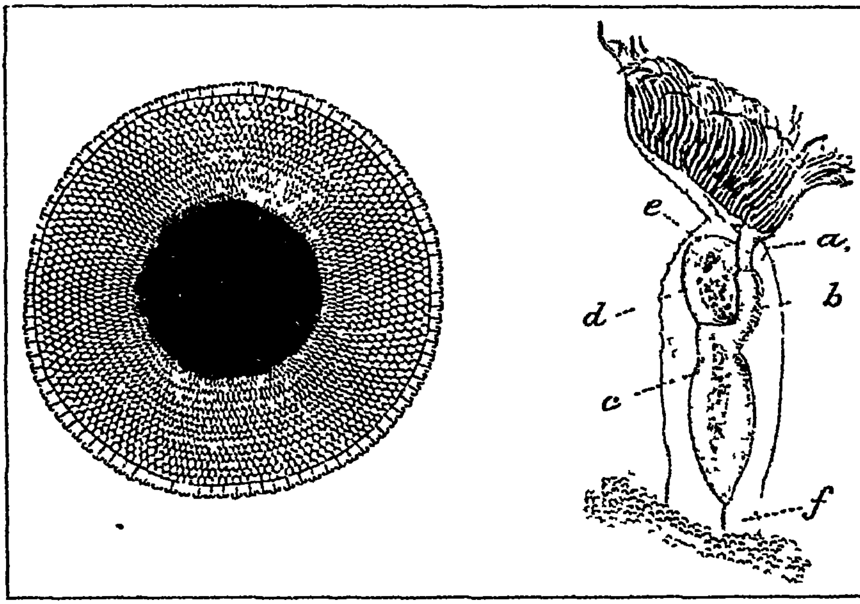
38 Pectinatella burmanica, *Annandale* (Plate III, fig 5)

Pectinatella burmanica, Annandale, Rec Ind Mus ii, p 174, fig 5 (1908)
Pectinatella burmanica, *id*, *ibid* v, p 56 (1910)
Pectinatella burmanica, *id*, Spol Zeyl vii, p 63, pl i, fig 3 (1910)

Zoarium The zoaria are circular or nearly so except when about to undergo division, in which case they are constricted in the middle As a rule they measure nearly an inch (2 cm) in

* It is now perhaps open to doubt whether the investment is actually secreted by the polyzoon, for Prof W West has discovered in it the cells of an alga belonging to a genus which habitually secretes a gelatinous investment of its own (see p 238, *post*) —*April 1911*

diameter The polypides have a definite arrangement in each zoarium, being divided into four groups, each of which has a fan-like form In the first place they are separated into two main divisions in a line running through the centre of the zoarium, and secondly each main division is separated into two subordinate ones in a line running across the other at right angles The number of zoaria joined together in a single compound colony is very variable, sometimes there are only about half a dozen and sometimes several hundreds The common investment in living colonies is often as much as two inches thick and has a translucent dark greenish colour due to the presence in it of green cells



B A

Fig 47 —*Pectinatella burmanica*

A = polypide with the lophophore expanded, ×15, *a* = œsophagus, *b* = cardiac limb of stomach, *c* = stomach, *d* = rectum, *e* = anus, *f* = funiculus [The muscles are omitted and the external tubercles are only shown on part of the polypide The specimen is from the Sur Lake, Orissa] B = statoblast from Ceylon, ×35

Polypide The polypide can be extruded for a distance of at least 5 mm Its whole external surface is covered with minute tubercles There are about 90 tentacles, which are long and slender, the velum at their base being narrow and almost straight The stomach is of considerable stoutness

Statoblast The statoblasts are of large size, measuring from 1 to 1 75 mm in diameter In form they are almost circular, but one side is always slightly flattened The marginal processes are very

short and bear a single pair of hooks at the tip The capsule is circular and small as compared with the free part of the swimming.

TYPE in the Indian Museum

P burmanica is evidently a near relation of *P gelatinosa*, Oka, from Japan, differing from that species in the shape of the statoblasts and in having much longer tentacles The arrangement of the polypides in the zoarium and the general structure of the statoblasts are very similar in the two species

GEOGRAPHICAL DISTRIBUTION.—*P burmanica* was originally described from a swamp at Kawkareik in the Amherst district of Tenasserim but has also been found in the Sur Lake near Puri in Orissa Dr A. Willey obtained specimens from a pool by the roadside between Maradankadewela and Galapitagala, at the foot of Ritigala, N Central Province, Ceylon

BIOLOGY.—The first specimen obtained was a statoblast fixed to a tube of the oligochæte worm *Aulophorus tonkinensis* taken at Kawkareik in March. At the same time young zoaria, which did not yet possess a common investment, were found on a leaf growing on a twig which drooped into the water Large compound colonies were taken in Orissa in October They completely encased the stems of reeds, thus forming hollow cylinders, but slipped from their supports when the reeds were pulled out of the water In life they resembled gelatinous algæ rather than animals and exhibited a striking similarity to masses of zoaria of *Lophopodella carteri* surrounded by such algæ Some of the colonies were evidently dying and contained few polypides in a living condition, but many statoblasts, others were in a flourishing condition and were producing larvæ and statoblasts simultaneously.

A piece of a colony full of larvæ was placed before midday in an aquarium, which was kept in a shady verandah Large numbers of larvæ were set free almost immediately They measured about 2 mm in length and were distinctly pear-shaped, each contained a pair of polypides, which occupied a comparatively small part of the interior the whole of the broader half being hollow The larvæ swam slowly, broad end-first, by means of the cilia with which their surface was covered, occasionally gyrating on their long axis and always adopting an erratic course Towards evening they showed signs of settling down, frequently touching the glass of the aquarium with their broad ends and sometimes remaining still in this position for some minutes Many attempts were, however, made before fixation was completed, and this did not occur until after nightfall. By next morning every larva was fixed to the glass and had everted its two polypides Unfortunately I was not able to trace the development further, but young compound colonies were found in which the secretion of the common investment had just commenced The zoaria in these colonies measured about 1 cm in diameter and already contained many polypides each

Oka has described the development from the statoblast of the allied Japanese species He found that each statoblast produced in the first instance a single polypide, and that the statoblasts, which were produced in autumn, lay dormant through the winter and germinated in spring As the Sur Lake begins to undergo desiccation as soon as the "rains" cease, the statoblasts in it probably do not germinate until the break of the next "rains" about the middle of June. I have had dried statoblasts in my possession for over two years Their cellular contents appear to be in good condition, although the cells show no signs of development, but they have not germinated in my aquarium, in which some of them have now been kept for more than six months

The green cells of the common investment are peculiar bodies that deserve further study than it has yet been possible to devote to them. Each cell is of ovoid form, varying somewhat in size but as a rule measuring about 0 03 × 0 008 mm. There can be no doubt that these bodies represent a stage in the life-history of an alga * Diatoms, bacilli and other minute plants are often present in the membrane as well as the characteristic green cells, but do not form a constant feature of it

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* Professor W West identifies this algæ as *Dactyloccopsis pectinatellophila*, new species It will be described, before the publication of this book, in the Journ As Soc Bengal (1911) Prof West has found, associated more or less fortuitously with *P burmanica*, another alga, namely *Microcystis orissica*, also a new species — *April 1911*

APPENDIX TO THE VOLUME.

Hints on the Preparation of Specimens.

To preserve Spongillidæ.—Spongillidæ must be preserved dry or in very strong alcohol. Formalin should not be used.

To clean siliceous sponge spicules.—Place small fragments of the dried sponge (if alcohol is present, the reaction is apt to be violent) in a test tube, cover them with strong nitric acid and boil over the flame of a Bunsen burner or small spirit lamp until the solid particles disappear. Add a large quantity of water to the acid and filter through pure cellulose filter-paper, agitating the liquid repeatedly. Pass clean water in considerable quantities through the filter-paper and dry the latter carefully; place it in a spirally coiled wire and ignite with a match, holding the wire in such a way that the spicules released by the burning of the paper fall into a suitable receptacle. They may then be picked up with a camel's-hair brush and mounted in Canada balsam.

To examine the skeleton of a Spongillid.—Cut thin hand-sections with a sharp scalpel, dehydrate if necessary, and mount in Canada balsam.

To prepare gemmules for examination.—Place the gemmules dry in a watch-glass with a few drops of strong nitric acid. When gas is given off freely add water in considerable quantities. Remove the gemmules with a camel's-hair brush to clean water, then to 50°/₀, 70°/₀, 90°/₀ and absolute alcohol in succession, leaving them for an hour in each strength of spirit. Clear with oil of cloves and mount in Canada balsam.

To ascertain the presence of bubble-cells in the parenchyma of a Spongillid.—Tease up a small piece of the sponge with a pair of needles, mount under a thin cover-slip in strong spirit, and examine under a high power of the microscope.

To preserve Hydra in an expanded condition.—Place the polyp in a watch-glass of clean water and wait until its tentacles are expanded. Heat a few drops of commercial formaldehyde and squirt the liquid while still hot at the *Hydra*, which will be killed

instantaneously Remove it to a solution of formaldehyde and spirit of the following formula —

Commercial formaldehyde	1 part
Absolute alcohol	3 parts.
Distilled water	7 parts

Then pass the *Hydra* through 50°/$_0$ and 70°/$_0$ alcohol and keep in 90°/$_0$

To examine the capsules of the nettle-cells.—Place a living *Hydra* in a small drop of water on a slide and press a thin cover-slip down upon it.

To preserve freshwater polyzoa in an expanded condition —Place the polyzoa in a glass tube full of clean water and allow them to expand their tentacles. Drop on them gradually when they are fully expanded a 2°/$_0$ aqueous solution of cocaine, two or three drops at a time, until movement ceases in the tentacles Then pour commercial formaldehyde into the tube in considerable quantities Allow the whole to stand for half an hour. If it is proposed to stain the specimens for anatomical investigation, they should then be removed through 50°/$_0$ and 70°/$_0$ to 90°/$_0$ alcohol. If, on the other hand, it is desired to keep them in a life-like condition they may be kept permanently in a solution of one part of commercial formaldehyde in four parts of water. Care must be taken that the process of paralyzing the polypides is not unduly prolonged, and it is always as well to preserve duplicate specimens in spirit or formalin with the lophophore retracted.

To prepare statoblasts for examination —Place the statoblasts for a few minutes in strong nitric acid. Then remove the acid with water, pass through alcohol, clear with oil of cloves, and mount in a small quantity of Canada balsam under a cover-slip, taking care that the statoblasts lie parallel to the latter

ADDENDA.

The following addenda are due mainly to an expedition to the lakes of Kumaon in the W Himalayas undertaken by Mr S W Kemp in May, 1911

PART I.

Genus SPONGILLA.

Subgenus EUSPONGILLA (p 69)

1 a Spongilla lacustris, subsp reticulata (p 71)

Specimens were taken in the lake Malwa Tal (alt 3600 feet) in Kumaon, while others have recently been obtained from the Kalichedu irrigation-tank in the Pagnor *talug* of the Nellore district, Madras (*G H. Tipper*)

4. Spongilla cinerea (p 79)

Specimens were taken in Naukuchia Tal (alt 4200 feet) in Kumaon They have a pale yellow colour when dry This sponge has not hitherto been found outside the Bombay Presidency

Subgenus EUNAPIUS (p 86).

8 Spongilla carteri (p 87)

Specimens were taken in Bhim Tal (alt 4450 feet) and Sat Tal (alt 4500 feet). Some of them approach the variety *cava* in structure

Subgenus STRATOSPONGILLA (p 100)

12 Spongilla bombayensis (p 102)

Add a new variety —

13 a. Var pneumatica, nov

This variety differs from the typical form in the following characters —

(i) The sponge forms a flat layer of a pale brownish colour as a rule with short and very delicate vertical branches

R

In one specimen it takes the form of an elegant cup attached, only at the base, to a slender twig

(ii.) The gemmules are covered, outside the spicules, by a thick pneumatic coat of irregular formation and with comparatively large air-spaces.

(iii.) The gemmule-spicules are regularly sausage-shaped.

TYPES in the Indian Museum

HABITAT Naukuchia Tal (alt. 4200 feet), Kumaon, W Himalayas (*S. W Kemp*)

Genus EPHYDATIA (p 108)

After *Ephydatia meyeni*, p 108, add :—

Ephydatia fluviatilis, *auct*

? *Ephydatia fluviatilis*, Lamouroux, Encyclop Méthod. ii, p 327 (1824)
Spongilla fluviatilis, Bowerbank (*partim*), Proc Zool Soc London, 1863, p 445, pl xxxviii, fig 1
Ephydatia fluviatilis, J E Gray (*partim*), Proc Zool Soc. London, 1867, p 550
Meyenia fluviatilis, Carter (*partim*), Ann Nat Hist (5) vii, p 92, pl vi, fig 11 *a*, *b* (1881)
Ephydatia fluviatilis, Vejdovsky, Abh k Bohm Gesellschaft Wiss xii, p 24, pl i, figs 1, 2, 7, 10, 14, 19 (1883)
Ephydatia fluviatilis, *id*, P Ac Philad 1887, p 178
Meyenia fluviatilis var *gracilis*, Potts, *ibid*, p 224
Meyenia robusta, *id*, *ibid*, p 225, pl. ix, fig 5.
Ephydatia fluviatilis, Weltner, Arch Naturg Berlin, 1895 (i) p 122
Ephydatia robusta, Annandale, Journ As Soc Bengal, 1907, p 24, fig 7
Ephydatia fluviatilis, Weltner, in Brauer's Susswasserfauna Deutschlands xix, Susswasserschwamme, p 185, figs 316, 317 (1909)
Ephydatia fluviatilis, Annandale, P U S. Mus xxxviii, p 649 (1910)

[Many more references to this common species might be cited, but those given above will be sufficient]

This species only differs from *E meyeni* in the following characters —

(i) there are no bubble-cells in the parenchyma,

(ii.) there is less spongin in the skeleton, which is less compact,

(iii) the gemmule-spicules are longer, the shafts being as a rule longer than the diameter of the rotulæ,

(iv.) the gemmules are armed with a single row of regularly arranged spicules embedded in pneumatic tissue with minute air-spaces

The sponge is a variable one and several "varieties" have been described from different parts of the world. My Indian specimens come nearest to the form described by Potts as *Meyenia robusta*, but have rather more slender skeleton-spicules and more elongate gemmule-spicules. The latter also appear to be less frequently "monstrous"

TYPE ?

GEOGRAPHICAL DISTRIBUTION.—*E fluviatilis* is widely distributed in Europe and occurs in N America,* S Africa (var *capensis*, Kirkpatrick), Australia, and Japan. Specimens were obtained by Mr. Kemp from several lakes in Kumaon, namely Naukuchia Tal (alt. 4200 feet), Bhim Tal (4450 feet), Sat Tal (4500 feet), and Naini Tal (6300 feet). The gemmules from Bhim Tal referred by me to *E robusta* (Potts) also belong to this species.

Biology. The external form of the sponge is due in great part to its environment. Specimens on small stones from the bottom of the Kumaon Lakes consist of thin disk-like films, often not more than a few centimetres in diameter and a few millimetres thick: others, growing on thin twigs, are elevated and compressed, resembling a cockscomb in appearance, while others again form nodules and masses of irregular form among the branches of delicate water-weeds. Some of these last are penetrated by zoaria of *Fredericella indica*.

Weltner has published some very interesting observations on the seasonal variation of minute structure in European representatives of the species (Arch. Naturg. Berlin, lxxiii (i), p 273 1907) and has discussed the formation of the abnormal spicules that sometimes occur (*ibid*. lxvii (Special Number), p. 191, pls vi, vii, figs. 27–59, 1901).

Genus CORVOSPONGILLA (p. 122).

After *Corvospongilla burmanica*, p. 123, add a new species —

Corvospongilla caunteri, nov

Sponge forming thin films of considerable area not more than 3 or 4 mm thick, of a bright green colour, moderately hard but friable. The surface smooth, oscula inconspicuous, surrounded by shallow and ill-defined radiating furrows, a very stout basal membrane present.

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* Most of the forms assigned by Potts to this species belong to the closely allied *E mülleri* (Lieberkuhn)

Skeleton reticulate but almost devoid of spongin, the reticulations close but formed mainly by single spicules, skeleton-fibres barely distinguishable A close layer of spicules lying parallel to the basal membrane

Spicules Skeleton-spicules variable in size and shape, almost straight, as a rule smooth, moderately stout, blunt or abruptly pointed, sometimes roughened or spiny at the tips, often sharply pointed Flesh-spicules minute, few in number with smooth, slender shafts which are variable in length, never very strongly

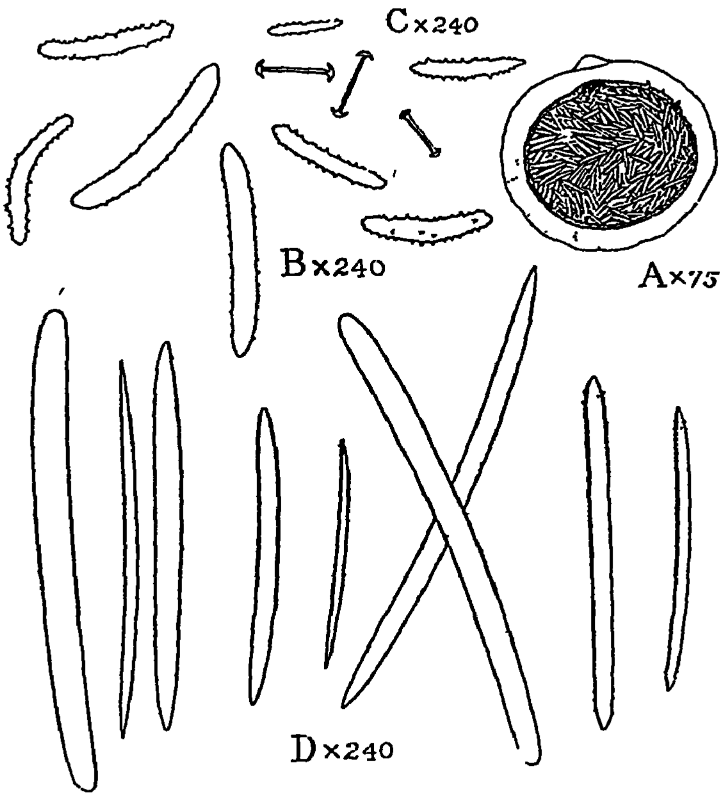

Fig 48 —*Corvospongilla caunteri* (type, from Lucknow)

A = Gemmule, B = gemmule-spicules, C = flesh-spicules, D = Skeleton-spicules

curved, the terminal spines relatively short, not strongly recurved Gemmule-spicules amphistrongylous or amphioxus, irregularly spiny, slender, of variable length

Gemmules free in the substance of the sponge, spherical or somewhat depressed, very variable in size but never large, having a thick external pneumatic coat in which the air-spaces are extremely small and, inside this coat, a single rather sparse layer of spicules lying parallel to the gemmule A single depressed aperture present.

TYPE in the Indian Museum.

HABITAT Hazratganj, Lucknow, on piers of bridge in running water (*J Caunter*, 29–30 iv 11)

The structure of the gemmules of this species differs considerably from that in any other known species of the genus, in which these structures are usually adherent and devoid of a true pneumatic coat In some of the gemmules before me this coat measures in thickness about $\frac{1}{9}$ of the total diameter of the gemmule *C caunteri* is the first species of *Corvospongilla* to be found in the Indo-Gangetic plain

PART II.

Genus HYDRA (p. 147)

25 **Hydra oligactis** (p 158)

Mr Kemp found this species common in Bhim Tal in May His specimens, which were of a reddish-brown colour in life, appear to have been of more vigorous constitution than those taken by Major Stephenson in Lahore Some of them had four buds but none were sexually mature

PART III.

Genus FREDERICELLA (p. 208)

28 **Fredericella indica** (p 210)

This species is common in some of the Kumaon lakes, in which it grows, at any rate at the beginning of summer, much more luxuriantly than it does in the lakes of the Malabar Zone in autumn, forming dense bushy masses on the under surface of stones, on sticks, &c The vertical branches often consist of many zoœcia Mr Kemp took specimens in Malwa Tal, Sath Tal, and Naini Tal (alt 3600–6300 feet)

Genus PLUMATELLA (p 212)

30 **Plumatella emarginata** (p 220)

Mr Kemp took bushy masses of this species in Malwa Tal and Bhim Tal

32 **Plumatella diffusa** (p 223)

This species is common in Malwa Tal and Bhim Tal in May

33 Plumatella allmani (p. 224)

Mr Kemp only found this species in Malwa Tal, in which (at any rate in May) it appears to be less abundant than it is in Bhim Tal in autumn Mr Kemp's specimens belong to the form called *P elegans* by Allman

34 Plumatella tanganyikæ (p 225)

Specimens taken by Mr Kemp, somewhat sparingly, in Bhim Tal and Sath Tal in May exhibit a somewhat greater tendency towards uprightness of the zoœcia than those I found in autumn in Igatpuri lake The ectocyst is, in the former specimens, of a deep but bright reddish-brown. The zoaria are attached to twigs and small stones

Genus STOLELLA (p 229)

After *Stolella indica*, p 229, add a new species —

Stolella himalayana, nov

This species may be distinguished from *S indica* by (i) its entirely recumbent zoœcia, and (ii) the lateral branches of its zoarium

Zoarium entirely recumbent, consisting of zoœcia joined together, often in groups of three, by slender, transparent, tubular processes. These processes are often of great relative length ; they

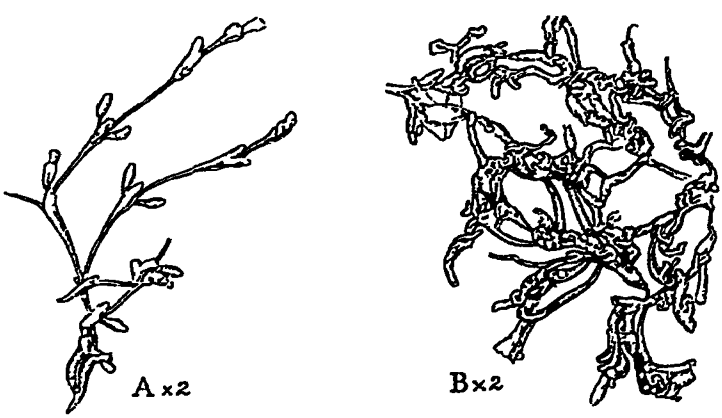

Fig 49 —*Stolella himalayana* (types, from the Kumaon lakes)

A. The greater part of a young zoarium B Part of a much older zoarium

are formed by a modification of the posterior or proximal part of the zoœcia, from which they are not separated by a partition, and they increase in length up to a certain point more rapidly than

the zoœcia proper A zoœcium often gives rise first to an anterior daughter-zoœcium, the proximal part of which becomes elongate and attenuated in due course, and then to a pair of lateral daughter-zoœcia situated one on either side As a result of this method of budding a zoarium with a close superficial resemblance to that of *Paludicella* is at first produced, but as the colony increases in age and complexity this resemblance largely disappears, for the zoœcia and their basal tubules grow over one another and often become strangely contorted (fig 49)

Zoœcia elongate and slender, flattened on the ventral, strongly convex on the dorsal surface, rather deep in proportion to their breadth, the ectocyst colourless, not very transparent except on the stolon-like tubular part, dorsal keel and furrow as a rule absent, orifice unusually inconspicuous, situated on a tubercle on the dorsal surface.

Polypide stout and short; the tip of the fundus of the stomach capable of very complete constriction, the retractor muscles unusually short and stout

Statoblasts Only free statoblasts have been observed They resemble those of *S. indica,* but are perhaps a little longer and more elongate.

TYPES in the Indian Museum.

The discovery of this species makes it necessary to modify the diagnosis of the genus, the essential character of which, as distinguishing it from *Plumatella,* is the differentiation of the proximal part of some or all of the zoœcia to form stolon-like tubules From *Stephanella,* Oka, it is distinguished by the absence of a gelatinous covering, and by the fact that all the zoœcia are attached, at least at the base, to some extraneous object

HABITAT. Malwa Tal, Kumaon (alt 3600 feet), W Himalayas (*Kemp,* May 1911)

BIOLOGY Mr. Kemp took three specimens, all attached to the lower surface of stones They contained few statoblasts and were evidently in a condition of vigorous growth Between the lateral branches new polyparia were developing in several instances from free statoblasts, each of which appeared to contain two polypides.

ALPHABETICAL INDEX.

All names printed in italics are synonyms
When more than one reference is given, the page on which the description occurs is indicated by thickened numerals

PLATE I.

SPECIMENS OF *Spongilla* PRESERVED IN SPIRIT.

Figs. 1–3. *S* (*Euspongilla*) *alba* var. *bengalensis* (nat. size) from ponds of brackish water at Port Canning in the delta of the Ganges. Fig 1 represents the type-specimen of the variety, and was taken in the winter of 1905–6. Figs. 2 and 3 represent specimens taken in the same ponds in the winters of 1907 and 1908 respectively.

Fig. 4. *Spongilla* sp (? abnormal form of *S* (*Eunapius*) *carteri*)) from an aquarium in Calcutta (× 10).

A C Chowdhary del

SPONGILLA

PLATE II.

PHOTOGRAPHS OF DRIED SPECIMENS OF *Spongilla*, *Tubella*, AND *Corvospongilla*

Fig 1. Part of a large specimen of *S.* (*Eunapius*) *carteri* from Calcutta, to show the conspicuous rounded oscula (reduced).

Fig. 2. Gemmules of *S.* (*Stratospongilla*) *bombayensis* on a stone from the edge of Igatpuri Lake, Bombay Presidency (nat. size).

Fig. 3 Part of one of the type-specimens of *S* (*Stratospongilla*) *ultima* from Cape Comorin, Travancore, to show the star-shaped oscula (slightly enlarged).

Fig. 4. Part of the type specimen of *T vesparioides* (external membrane destroyed), to show the reticulate skeleton and the numerous gemmules (nat. size)

Fig. 5. Part of a schizotype of *C. burmanica* to show the elevated oscula (nat size)

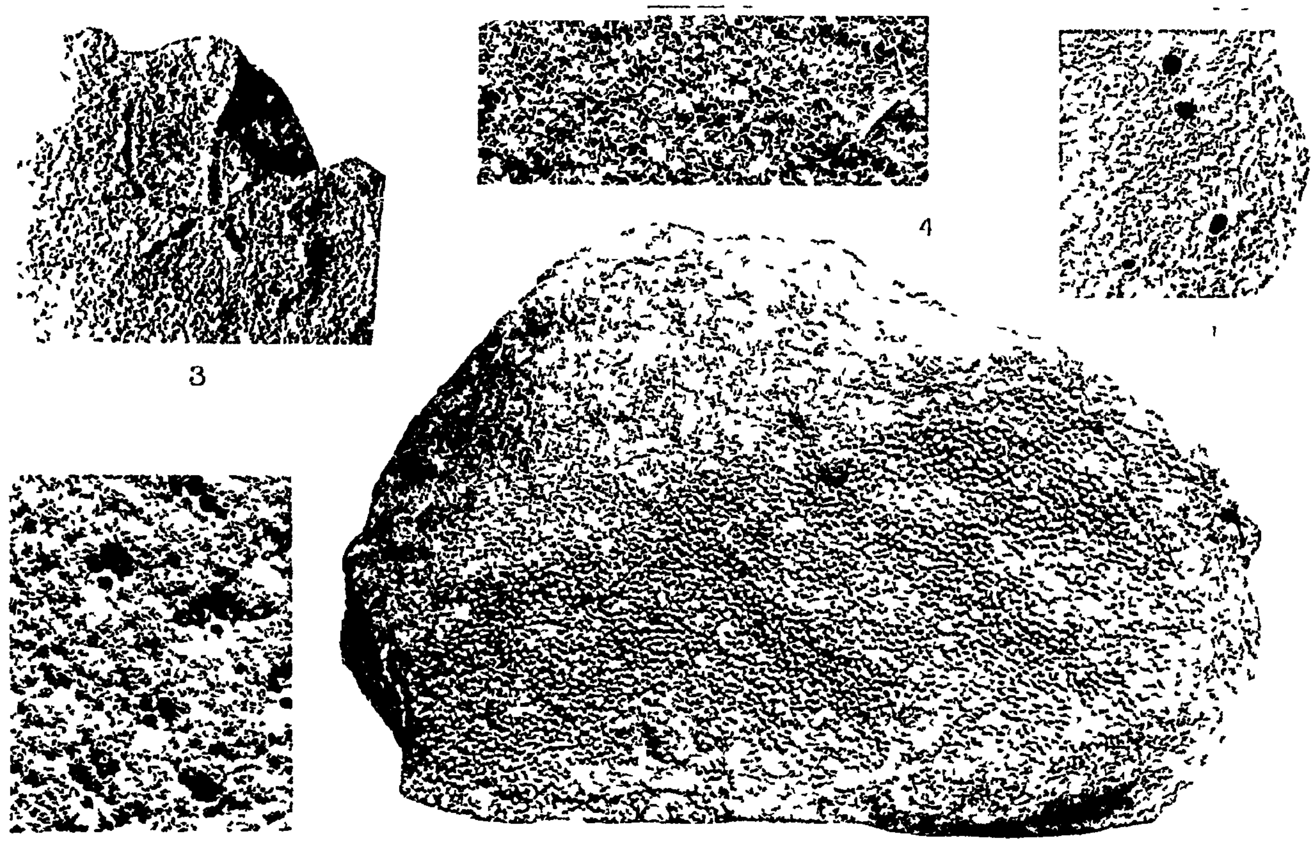

Photo by A. Chowdhary

Spongilla, Tubella, Corvospongilla

PLATE III.

PHOTOGRAPHS OF SPECIMENS OF *Plumatella*, *Lophopodella*, AND *Pectinatella*.

Fig 1 Specimen in spirit of *P fruticosa* (typical form) on the leaf of a bulrush from a pond in the Calcutta Zoological Gardens (nat. size).

Fig 2 A small zoarium of the *benedeni* phase of *P emarginata* from Rangoon (nat size) Part of the mass has been removed at one end to show the structure. The specimen was preserved in spirit.

Fig 3 Part of a large zoarium of *P diffusa* on a log of wood from Gangtok, Sikhim (nat size) An enlarged figure of another part of the same specimen is given in fig 2, Pl. IV. The specimen was preserved in spirit

Figs 4, 4*a* Specimens of *L carteri* from Igatpuri Lake, Bombay, preserved in formalin Fig 4 represents a mass of polyparia surrounded by a green gelatinous alga on the stem of a water-plant, fig. 4*a* an isolated polyparium with the polypides fully expanded from the under surface of a stone in the same lake Both figures are of natural size.

Fig. 5. Part of a compound colony of *P. burmanica* on the stem of a reed from the Sur Lake, Orissa (nat. size, preserved in formalin).

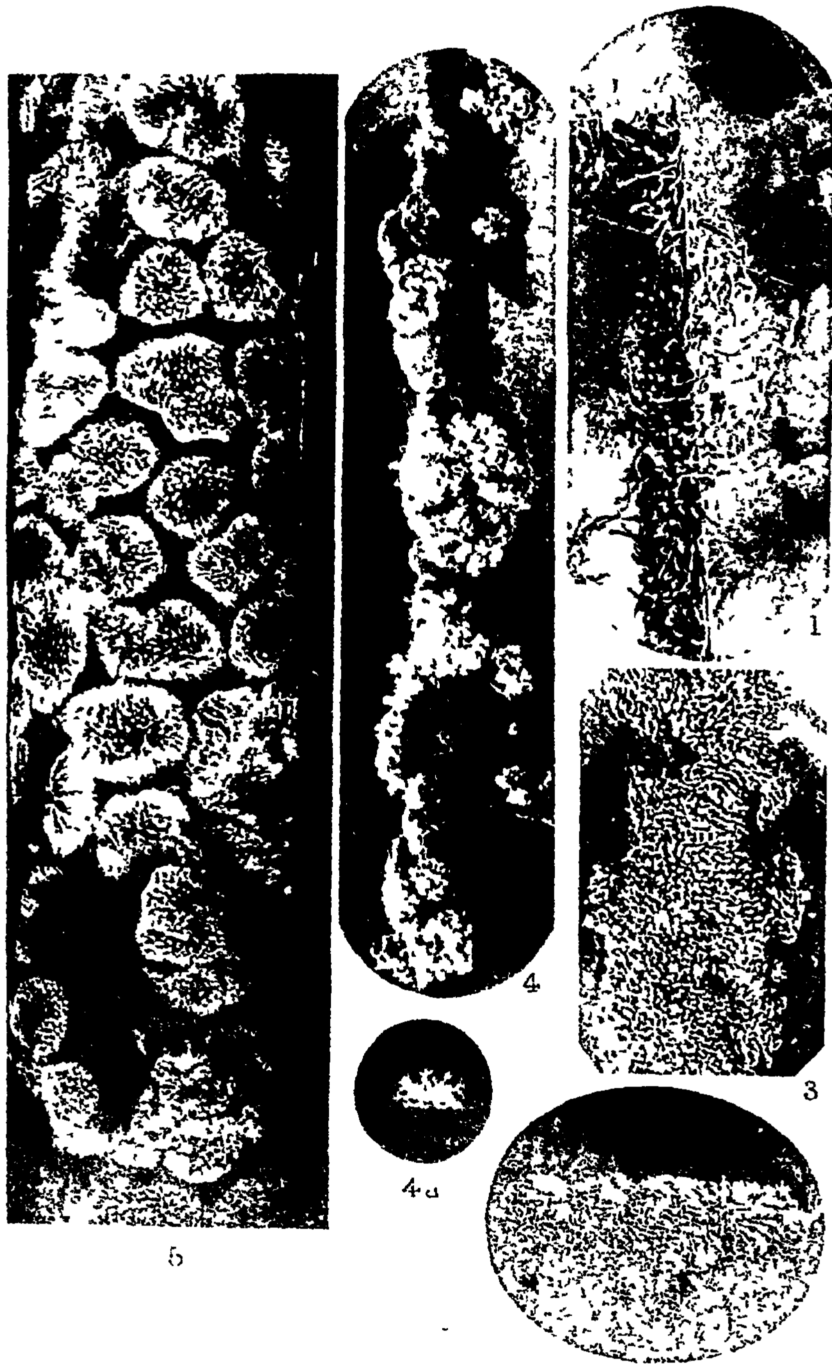
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PLATE IV.

SPECIMENS OF *Plumatella*.

Fig. 1 Vertical branch of a polyparium of *P. emarginata* from Calcutta, to show method of branching ($\times 8$). The specimen was preserved in formalin, stained with hæmalum, and after dehydration and clearing, mounted in canada balsam.

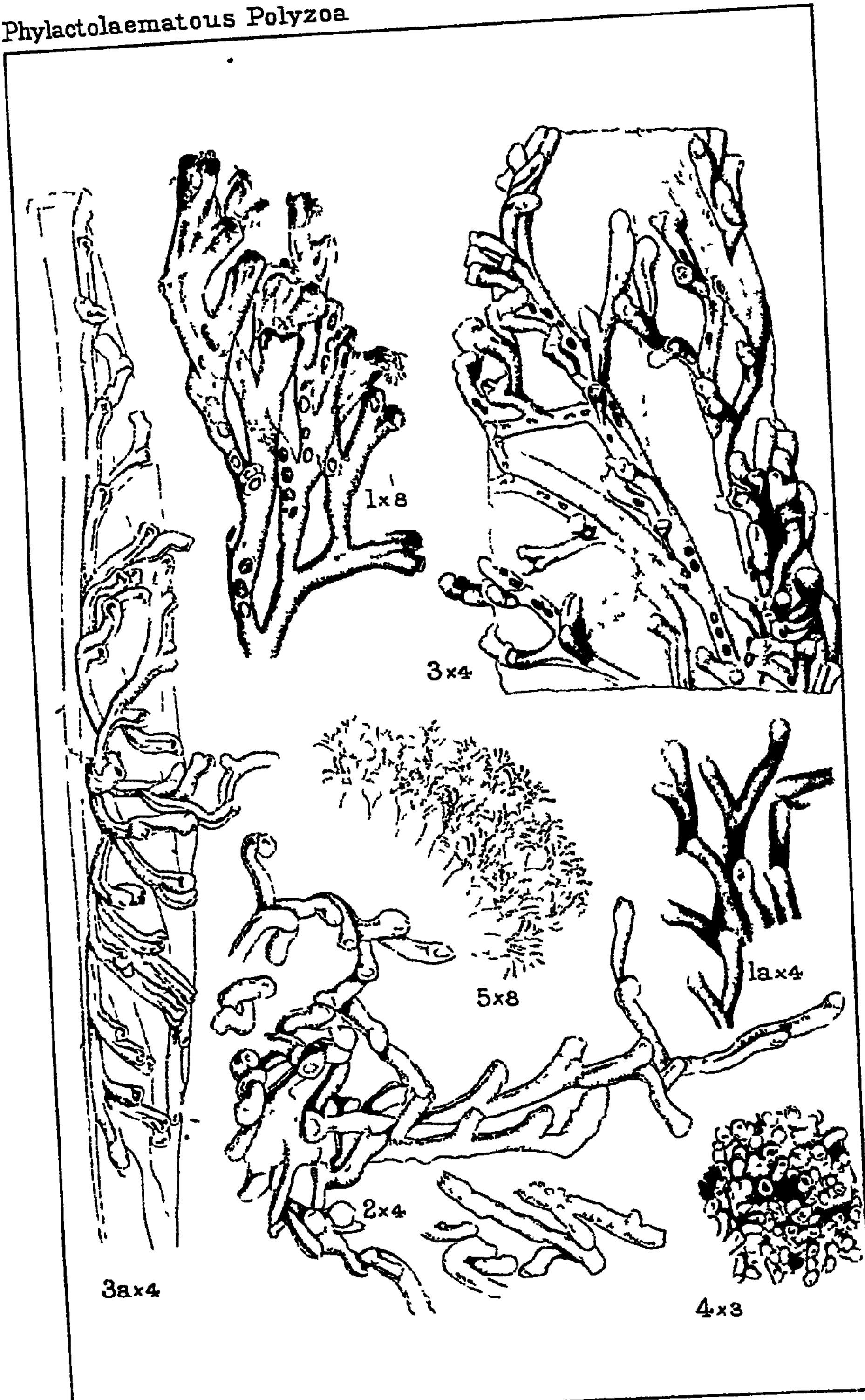
Fig 1 *a* Part of a young, horizontal zoarium of *P. emarginata* from Rangoon ($\times 4$, preserved in spirit).

Fig 2 Part of a zoarium of *P diffusa* from Gangtok, Sikhim ($\times 4$) See Pl. III, fig. 3.

Figs 3, 3 *a* Specimens in spirit of *P allmani* from Bhim Tal (lake), W Himalayas Fig 3 represents a mature polyparium, fig 3 *a* a young polyparium to which the valves of the statoblast ($\times$) whence it had arisen are still attached

Fig. 4 Part of a zoarium of the *coralloides* phase of *P. fruticosa* (from Calcutta) preserved in spirit as seen on the surface of the sponge in which it is embedded ($\times 3$)

Fig. 5. Part of the margin of a living polyparium of *P punctata* from Calcutta ($\times 8$) with the polypides fully expanded.



A C Chowdhary, del

PLUMATELLA

PLATE V.

SPECIMENS OF *Plumatella*, *Stolella*, AND *Pectinatella*.

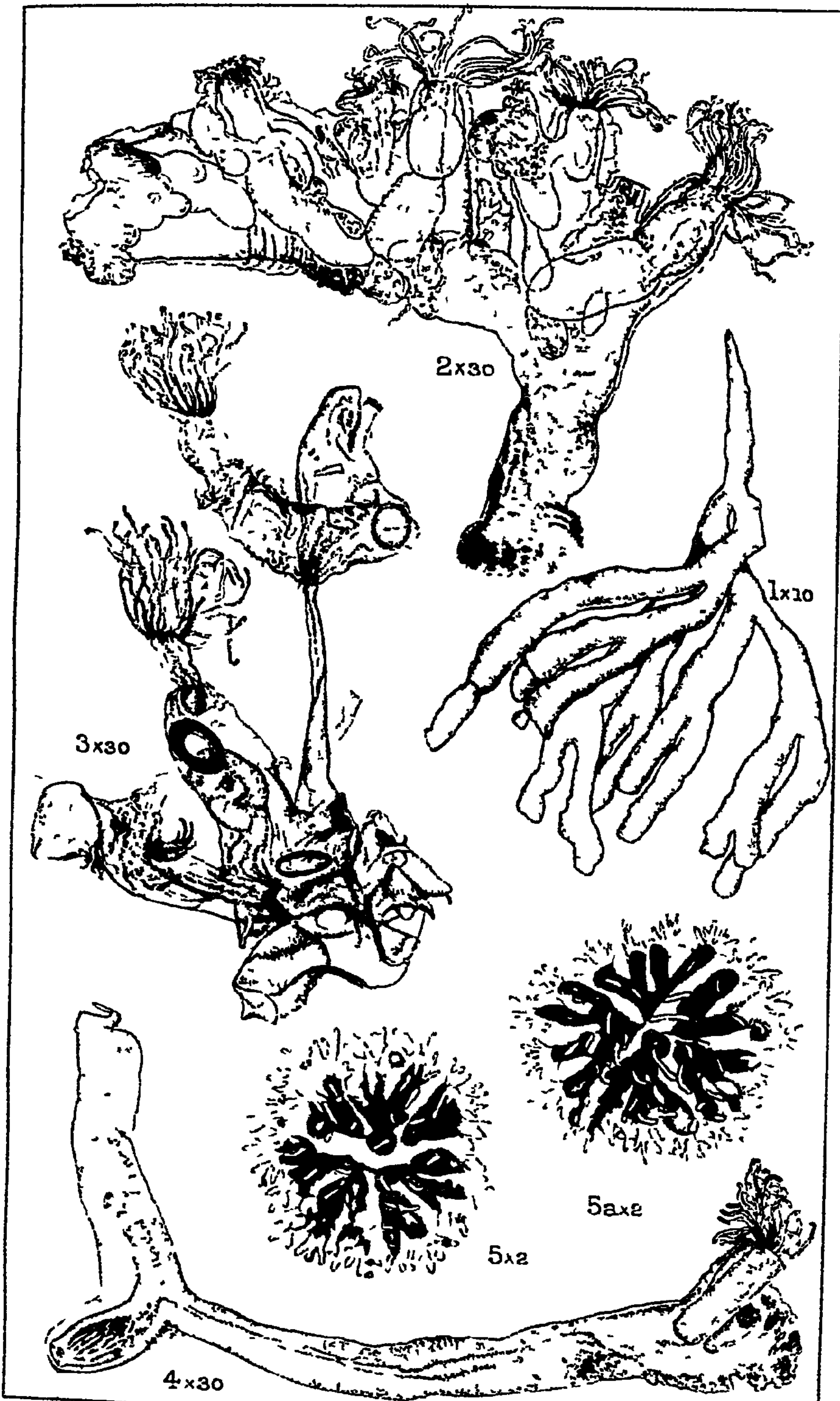
Fig 1. Part of a zoarium of the *coralloides* phase of *P. fruticosa* (×10) from Calcutta The specimen, which was preserved in spirit, had been removed from a sponge of *Spongilla carteri*.

Fig. 2 Terminal branch of a polyparium of *P punctata* from Calcutta (× 30) The specimen was preserved in formalin, stained with hæmatoxylin, and finally mounted in canada balsam.

Fig. 3. Part of an adult polyparium of *S indica* from the United Provinces (× 30) The specimen was preserved in formalin, stained with hæmalum, and finally mounted in canada balsam The lower zoœcium contains a mature free statoblast, the upper one a fixed one

Fig 4 The growing point of a young polyparium of the same species from Calcutta (×30), to show the method of formation of the stolon that connects the different groups of zoœcia The specimen had been treated in the same way as that represented in fig. 3

Figs 5, 5 *a* Zoaria from a compound colony of *P. burmanica* from the Sur Lake, Orissa (×2) The specimens, which were preserved in formalin, are represented as seen from the adherent surface of the colony



A C Chowdhary, del

Plumatella, Stolella, Pectinatella